# Peace Project Water Use Plan

## Williston Dust Control Monitoring

## Implementation Year 8

## Reference: GMSMON-18

***BC Hydro Williston Reservoir Air Monitoring 2015 Annual Report***

**Study Period: January 2015 to December 2015**

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# **GMSMON#18 WLL Dust Control Monitoring**

## BC Hydro Williston Reservoir Air Monitoring 2015
## Annual Report

Chu Cho
ENVIRONMENTAL

Prepared For: BC Hydro and the Joint Planning Committee
Prepared By: Chu Cho Environmental
Study Period: 2015/01/01 – 2015/12/31

Tsay Keh Dene, BC, V0J 3N0

**GMSMON#18 WLL DUST CONTROL MONITORING**

**PREPARED FOR:**

BC HYDRO AND THE JOINT PLANNING COMMITTEE

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**Executive Summary:**

Chu Cho Environmental began operating and maintaining the GMSMON#18 Williston Reservoir regional air quality monitoring network in March of 2014 (year 7 of the project) and continued work in 2015 (year 8 of the project). GMSMON#18 is a 10-year air quality monitoring program that is designed to assess the impact of dust mitigation treatments on Aeolian dust emissions from the Finlay Reach of the Williston Reservoir. The program was expanded in year 4 to include Federal Reference monitoring for the development of baseline ambient air quality data in the villages of Tsay Keh Dene and Kwadacha. The Federal Reference data will be used to contextualize the northern Finlay Valley region within the air quality standards developed by the BC Ministry of Environment (BC MoE) and the Canadian Council of Ministers of the Environment (CCME). Year-4 also included a significant change in instrumentation and the development of additional monitoring sites.

Following the rationale of the monitoring program Terms of Reference - Addendum 3, Chu Cho Environmental revised the network design in 2014 to increase the spatial and temporal resolution of the data. This has allowed for a better evaluation of the impact of dust mitigation treatments on fugitive emissions from the reservoir beaches.

Chu Cho Environmental views GMSMON#18 as having two distinct network components, each of which addresses a different question posed in the GMSMON#18 Addendum 3 document:

1. The **Regional Monitoring Network** comprises 18 E-Samplers and 8 Meteorology Monitoring sites. This network is designed to assess the impact of dust mitigation treatments on Aeolian dust emissions from the Finlay Reach of the Williston Reservoir.
2. The **Reference Monitoring Network** is comprises 2 TEOM Monitoring stations and 2 Meteorology Monitoring stations. This network is used to evaluate the regional ambient air quality within the context of the guidelines and standards developed by the BC MoE and the CCME.

The analysis for each of these network components has been separated into two sections for this report. The intended use and Data Quality Objectives for each network component are stated at the beginning of each section.

The GMSMON#18 air quality monitoring project exists because of the fugitive dust created by annual reservoir operations that results in the exposure of large expanses of loose sediment with little vegetative cover or other protection from wind erosion. These sediments are primarily a loosely packed glacial till consisting of gravel, sand, silt and clay with minimal organic content. At full-pool, or 672m above sea level, these sediments are covered by 10 – 15 meters of water and are not exposed to wind erosion. In November, the reservoir freezes and the water inputs are less than the output at the dam, resulting in continued drawdown until the reservoir water level reaches 655m above sea level (this varies from year to year depending on power demand and precipitation but cannot currently go below 655m asl). Following spring

thaw and the melting of the ice, the expanses of sediment are exposed for several months before the reservoir is recharged. During these months the prevailing winds and seasonally changing weather patterns result in periods of wind erosion. Analogous to a push broom on a driveway, the wind erosion results in dust storms that develop locally and if winds are sustained, the dust storms will migrate with the wind, eventually filling the valley with airborne sediment. It is during the erosive spring months that dust mitigation techniques are applied to the reservoir sediment expanses in order to slow or stop the erosion. The mitigation program is called the Williston Dust Mitigation Program (WDMP) and is administered by Chu Cho Industries LP. The primary goal of GMSMON#18 is to evaluate the impact of these mitigation techniques at both a local and regional scale through the monitoring of suspended sediment in the air.

Utilizing the Regional Monitoring Network, Chu Cho Environmental has developed and will continue to refine analysis techniques that provide new insight into the development, evolution and migration of dust storms in the Finlay Valley. We have incorporated spatial techniques such as heatmap analysis and linked this with time-lapse imagery and video editing software to create strong visual tools. This allows us to observe dust storms and the associated particulate matter data values. Chu Cho Environmental will continue to refine our analysis and data capture techniques to better address the key management question in years 9 and 10 of the program.

This report demonstrates the direction and approach that Chu Cho Environmental has began to implement for the investigation of the data captured by the monitoring equipment. More data collection is required before strong conclusions can be reached. For year-2 of Chu Cho Environmental operation, our project team focused streamlining the analysis techniques and building the required models to address the management question, while simultaneously increasing the security and reliability of the data sources. These advances will be detailed in this report.

In general, the spatial and temporal variability between sites is large. A dust event is identified as exceeding the threshold of 0.1 $mg/m^3$ Total Suspended Particulate (TSP) for more than 30 minutes. The rationale behind this definition is expanded upon in Section 2. It should be noted that this is not a regulatory threshold. Some sampling stations had more than 100 dust events over the 2015 dust season, whereas other sites had as low as 2. The average was 56 dust events. Some events are short lived and highly localized to an individual beach or group of beaches, while others fill large sections the valley. Overall, 2015 was not a dusty year with none of the usual major storm events that our project team has observed year after year since 2008. The development of this new monitoring network allows our team to observe dust events beginning in one location and then migrating in response to sustained wind events. The distributed network of sample stations has allowed us to evaluate the relative contribution of local areas to the overall quantity of airborne sediment in the valley.

For 2015, we have also continued evaluating the before and after effects of applying tillage to beaches on the reservoir as a mitigation technique. There are significant data limitations preventing conclusive analysis through our technique here but in general there is limited evidence to suggest that applying tillage to a given beach will result in a direct reduction in airborne dust over time. So far, the test cases have presented statistically significant but confounding results, in some cases tillage appears to significantly reduce dust emissions after its application and in others it appears to significantly increase emissions after its application.

Many of these results are linked to multiple confounding variables such as precipitation and wind speed and it has been the bulk of our effort to unpack and evaluate the results by controlling for these environmental variables. Chu Cho Environmental does not believe that the analysis has been rigorous enough to provide conclusions with regards to these results. We will continue to add to this dataset moving forward in order to develop conclusive answers to this primary investigation.

Chu Cho Environmental has continued to manage the Reference Monitoring Network to the standards of the CCME and will provide a basic analysis of these data following the CCME guidelines. The 2015 dust season was below average showing only one minor 24-hour exceedence of the provincial objectives for $PM_{10}$ and no exceedences of the Federal standards for $PM_{2.5}$ between April and June. It should be noted that the data collected by the Reference Monitoring Network are not used to directly address the key management question posed in the Terms of Reference for GMSMON#18, but are used to characterize the long term regional ambient air quality in Tsay Keh Dene and Kwadacha. The data from this network has provided and will continue to provide valuable insight into the long-term air quality trends within the region.

In addition to managing the air quality monitoring networks there were three other additional program components identified in the Addendum 3 document, these include:

1. Dustfall Monitoring,
2. Mentorship and Capacity Building Objectives, and
3. Community Engagement.

Year-1 of Chu Cho Environmental's control over GMSMON#18 included many successes and learning opportunities. Year-2 included an early deployment (April 7th, 2015), procedural refinement and the development of numerous processing algorithms to help improve the project. Our project team found many efficiencies and opportunities to improve the program.

Chu Cho Environmental will continue to advance the GMSMON#18 program through improved data collection procedures, analysis techniques and the application of advanced statistical analysis techniques.

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# 1.0 Finlay Valley Airshed and Williston Dust Monitoring

## 1.1 Finlay Valley Airshed

The Finlay Valley extends from the Peace Arm of the Williston Reservoir north towards Tsay Keh Dene and Kwadacha villages.

The Finlay Valley is part of the northern Rocky Mountain Trench, residing between the Rocky Mountains to the east and the Omineca Mountains to the west. The Rocky Mountain Trench formed shortly after the end of the Laramide Orogeny and the formation of the Rocky Mountains when the land was rebounding after the tectonic pressure was relieved and before the development of the Omineca Mountains (Canning et al., 1999).

The region has seen many glaciations in the last 200 million years, the last of which left the area approximately 9000 years ago. Successive glaciations deposited large volumes of sediment through various lacustrine and fluvial processes leaving the Finlay Valley and Rocky Mountain Trench with an extensive layer of glacial overburden that comprises massive sand and gravel benches interlaced by fine lacustrine unconformities. The Williston Reservoir now sits in the northern Rocky Mountain Trench having flooded over 1,775 $km^2$ of valley bottom. Annual operation of the W.A.C. Bennett dam can change the reservoir surface elevation from 655m to 672m above sea level, leaving beaches, cutbanks and gravel outcrops exposed for several months during the spring freshet period.

Successive glaciations and river incision have created a valley that is broad and U-shaped, but is also deeply incised by the Finlay and Parsnip rivers. Given the shape of the valley the annual fluctuation in reservoir level has the potential to expose massive expanses (~20,000 Ha) of loose erodible sediment during the spring months before the reservoir is recharged following spring freshet. While the water is low, the exposed beaches, which are composed of mixed sand, silt, clay, and gravel beds tend to erode during spring wind events resulting in the emission of large amounts of fugitive dust.

Winds in the northern Rocky Mountain trench tend to follow the orientation of the valley, flowing either Northwest or Southeast. There are many arms along the reservoir which generate valley cross winds at different times of the year. Generally, the ground level winds in this area are steered by the orientation of the valley. This means that southerly winds drive the airborne fugitive dust from the reservoir beaches directly along the Rocky Mountain Trench northward where they pass through Tsay Keh Dene and Kwadacha.

The airborne dust arriving in Tsay Keh Dene and Kwadacha is a nuisance and poses a potential health threat when concentrations exceed Canadian Ambient Air Quality Standards (CAAQS).

## 1.2 Management Summary: GMSMON#18 Management Questions and Program Components

The dust control management plan (DCMP) under Section 5.1 of the Peace River Water Use Plan (WUP) was implemented with the goal of reducing the duration and magnitude of the dust storms that affect the quality of life for people living adjacent to the reservoir (BC Hydro, 2007). The DCMP consists of three major components: dust source surveys, erosion control trials and Air Quality (AQ) monitoring.

The AQ monitoring component of the DCMP is the result of a 10-year commitment (2008 to 2018) by BC Hydro to measure the fugitive dust emissions that result from the annual operations of Gordon M. Schrum Hydro Power Facility and the Williston Reservoir. The purpose of the AQ monitoring program is to quantify the levels of Particulate Matter (PM) in the air shed surrounding the reservoir. The results of the AQ monitoring program are integral in formalized dust control audit procedures for testing the overall effectiveness of the erosion control methods employed by the WDMP. Theoretically, a successful erosion control program will result in diminished PM emissions observed by the AQ monitoring network. The key management question for this program as defined in the GMSMON#18 ToR document is:

**What is the impact of dust mitigation treatments on Aeolian dust emissions from the Finlay Reach of the Williston Reservoir?**

The results of this AQ monitoring program will provide input into adaptive management of dust mitigation plans for the Williston Reservoir and will inform water use decisions as they pertain to dust control as identified in the ToR Addendum 3 Section A3.2.5. Ultimately, some of the analysis avenues investigated in this annual report may be changed as required in favor of more concise analyses that become available once we have amassed sufficient data. Other avenues included in this analysis may be foundational and will be the building blocks of what is to come in future iterations of this report.

The following table provides a summary of the various program components that pertain to year-8 of GMSMON#18 and the status of those components:

**Table 1: Management Summary - Status of GMSMON#18 Program Components**

| Program Component | Management Question | Management Hypothesis (Null) | Status |
|---|---|---|---|
| **Regional Monitoring Network** | Do the dust mitigation activities result in decreased regional or local dust emissions? | Dust mitigation activities do not result in a reduction of dust emissions when evaluated at either a regional or local scale. | 18 E-Samplers and 8 Meteorology sites were deployed in 2015 to address this question. The samplers are collecting data at 5 minute intervals from April to October. Statistical analysis of data from 2014 indicated that mitigation activities are have |

| | | | |
|---|---|---|---|
| | | | minimal effect on reducing local/regional fugitive emissions. 2015 was a year of little wind and limited dust activity (like no other year in our 8-year dataset) that did not result in highly descriptive or statistically significant data. Currently it is not possible to delineate mitigation treatment effects from the numerous confounding variables such as rainfall, relatively humidity and reservoir rise. In order to conclusively address the key management question, 2016 must be a windy and dusty year. |
| **Reference Monitoring Network** | Are the long-term ambient air quality values for $PM_{10}$ and $PM_{2.5}$ in Tsay Keh Dene and Kwadacha within the provincial Air Quality Objectives (AQOs) and Federal Standards (CAAQS)? | The ambient air quality values for $PM_{10}$ and $PM_{2.5}$ in Tsay Keh Dene and Kwadacha do not meet the provincial AQOs nor the CAAQS. | There was only a single exceedence of the provincial AQOs and zero exceedences of the Federal Standards during the 2015 dust season. This may be related to the dearth of windy days and relatively quick inundation of the reservoir beaches during the 2015 dust season In this report we have again provided additional analysis of the TEOM data by examining the total daily hours above the AQOs. This is in no way meant as a surrogate to the Federal or Provincial standards but speaks to the event driven nature of the dust events in Tsay Keh Dene. |
| **Dustfall Monitoring Network** | Are the baseline dustfall values within the bounds of the provincial Air Quality Objectives? | Dustfall values recorded in Tsay Keh Dene are not above the provincial AQOs for monthly dustfall. | Dustfall monitoring was initiated in 2015 but only a single sample round was collected for May 2015. All three dust fall sample stands were vandalized beyond repair and in some cases were tossed into the reservoir. New sample stands were ordered but were not ready for deployment until after the dust season. They will be deployed again in 2016. |
| **Mentorship** | n/a | n/a | Chu Cho Environmental |

| | | | |
|---|---|---|---|
| **and Community Engagement** | | | employees who reside in Tsay Keh Dene or Kwadacha are steadily taking on more responsibilities for AQ monitoring. Our Tsay Keh crew members are responsible for monthly instrument maintenance and data management for the regional monitoring network. For 2016, these employees will be trained on management of the TEOM Reference Monitoring System. Chu Cho Environmental has participated in various community events and open houses to promote the AQ monitoring program. |
| **Enhanced Data Security, Transparency and Access** | n/a | n/a | New computer systems have been installed to improve network security and reliability. We have enlisted third party applications for hosting data online and have implemented a remote log in system to allow remote access to the instrumentation. Currently anyone who wishes could be added to an email list serve and could receive a .csv file summarizing the previous 12 hours of data. Data are all synced via Dropbox and are analyzed shortly after using Matlab. |

### 1.2.1 Updates to Monitoring Network

Chu Cho Environmental did not implement any major changes to either of the monitoring networks for the 2015 dust season and proposes no major changes for 2016.

Only 4 minor changes were made to the Regional Monitoring Network in order to improve the overall coverage of the meteorology and dust sampling equipment, these include:

1. Meteorology Station Moved from Davis South to Davis North:

a. The Davis South station is only exposed to southerly winds and does not adequately capture north winds. We moved the meteorology station to Davis North beach to a location that had 360 degree wind exposure. The E-Sampler from Davis South was left in place.

2. E-Sampler removed from Lafferty Beach and placed at Tsay Keh Dene Beach:

   a. It was determined that coverage was adequate in the Lafferty area with neighboring sites 35km, Collins and Moody. The E-Sampler located in Tsay Keh Village is used for direct comparison to the near by TEOM leaving the beach under represented in the dataset. For this reason, an E-Sampler was deployed on Tsay Keh Beach in the foreshore zone.

3. Sampling with BGI PQ200's discontinued:

   a. As per our operational plan, use of the BGI PQ200 samplers was discontinued in 2015. BGI PQ200 data were collected in 2014 for comparison to E-Sampler data but the cost to operate the PQ200's is prohibitively expensive for what little data they provide in the context of this management question.

4. Sampling discontinued at Stromquist:

   a. The Stromquist sampling site was considered poor quality. The site is located in a sheltered embayment with low wind exposure and no nearby erodible sediment. For these reasons sampling at this site was discontinued in 2015.

## 1.3 Data Summary

The following tables provide a detailed summary of all of the components involved in this program and the rate at which each component is collecting data:

**Table 2: Summary of Air Quality Response Measures Monitored**

| | **Response Measures** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Spatial Data** | **Dustfall** | | **Total Suspended Particle Concentration** | | **Particulate Matter Concentration** | | **Particulate Matter Concentration** | |
| | **Shapefile Data** | **Volatile** | **Fixed** | **All levels** | **All Levels** | **PM2.5** | **PM10** | **PM2.5** | **PM10** |
| **Variable ID** | | DF-TK-1-3 | DF-TK-1-3 | 001 - 030 | name | pm25 | pm10 | BGI_pm 25 | BGI_pm 10 |
| **Sampling Year(s)** | 2015 | 2014-2015 | 2014-2015 | 2014-2015 | 2014-2015 | 2011-2015 | 2011-2015 | 2011-2013 | 2011-2013 |
| **Sampling Frequency** | once | monthly (May-Oct) | monthly (May-Oct) | 5 min (May-Jun) | 10 min | 10 min (May-August) | 10 min (May-August) | 1 in 6 day (May-Sept) | 1 in 6 day (May-Sept) |
| **Measurement Units** | UTM | $mg/dm^2/day$ | $mg/dm^2/day$ | $mg/m^3$ | per photo | $\mu g/m^3$ | $\mu g/m^3$ | $\mu g/m^3$ | $\mu g/m^3$ |
| **N** | lot | 3 | 3 | 19 | 8 | 2 | 2 | 8 | 8 |
| **Data type** | shapefile | measured | measured | measured | estimated | measured | measured | measured | measured |
| **Equipment** | Trimble Juno | Dustfall canisters | Dustfall canisters | E-sampler | Moultrie D-555i Game Camera | TEOM 1405-D | TEOM 1405-D | BGI PQ200 | BGI PQ200 |

### Table 3: Summary of Meteorological Equipment Used in GMSMON#18

| | Meteorology Monitoring | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Wind Speed | | Wind Direction | | Relative Humidity | | Rainfall | | Air Temperature | | Air Pressure |
| | | | | | | | | | | | |
| **Variable ID** | ws | ws | wd | wd | rh | rh | prcp | prcp | temp | temp | press |
| **Sampling Year(s)** | 2014 | 2011-2014 | 2014 | 2011-2014 | 2014 | 2011-2014 | 2014 | 2011-2014 | 2014 | 2011-2014 | 2011-2014 |
| **Sampling Frequency** | 5 min (May-Sept) | 10 min (Jan-Dec) | 5 min (May-Sept) | 10 min (Jan-Dec) | 5 min (May-Sept) | 10 min (Jan-Dec) | 5 min (May-Sept) | 10 min (Jan-Dec) | 5 min (May-Sept) | 10 min (Jan-Dec) | 10 min (Jan-Dec) |
| **Measurement Units** | m/s | m/s | degrees | degrees | % | % | mm | mm | degrees celcius | degree celcius | kPa |
| **N** | 8 | 2 | 8 | 2 | 8 | 2 | 8 | 2 | 8 | 2 | 2 |
| **Data type** | measured | measured | measured | measured | measured | measured | measured | measured | measured | measured | measured |
| **Equip.** | Met Station | TEOM 1405-D | Met Station | TEOM 1405-D | Met Station | TEOM 1405-D | Met Station | TEOM 1405-D | Met Station | TEOM 1405-D | TEOM 1405-D |

# NETWORK COMPONENT I: REGIONAL MONITORING NETWORK

# 2.0 Regional Monitoring Network

## 2.1 Network Characterization

The Regional Monitoring Network is designed to assess the impact of dust mitigation treatments on Aeolian emissions from the Finlay Reach of the Williston Reservoir. This network was not altered significantly for 2015, the only minor changes were identified above in Section 1.2.1. The Regional Monitoring Network consists of 18 MetOne E-Samplers and 8 micro-meteorology monitoring stations. The 18 E-Samplers are dispersed across the many cutbanks, points, beaches and gravel bars in the reservoir's Finlay Arm.

Some locations such as Chowika, Ingenika, and Lafferty are situated on large gravel bars or rock out crops that do not produce dust. The dust recorded at these locations is coming from elsewhere further upwind within the reservoir basin. Other sites such as Middle Creek North, Shovel and 35km are situated directly on or very near to beaches that are known high dust emitters. Samplers located on or near beaches are generally good indicators of the local dust conditions. The number of samplers deployed was limited to site accessibility and the number of available instruments.

E-Samplers are designed to measure continuous air quality data at 1Hz and can record that data at various averaging intervals. We are currently using the 5-minute averaged data option, which allows the units to function autonomously for up to 15 days before the on-board memory is full and requires downloading. E-Samplers are designed to measure either Total Suspended Particulate (TSP), $PM_{10}$, or $PM_{2.5}$ but they cannot measure all three. Through joint planning and consultation it was determined that measuring TSP was the priority for the Regional Monitoring Network. TSP includes all size fractions of fugitive particulate that may be ejected into the air from reservoir beaches by wind erosion.

Alongside the 18 E-Sampler sites there are 8 meteorology monitoring stations. With the exception of Davis South being moved to Davis North and sampling being discontinued at Stromquist (Met Station Moved to 57Km), the meteorology stations were placed in the same locations as previous years. Each meteorology station is outfitted with a rain gauge, temperature probe, relative humidity sensor, wind vane, and anemometer. The data are logged using a CR1000 datalogger.

Ultimately, the location of the 18 sample sites was determined by accessibility and the characteristics of the site that adequately represent the airshed in that local zone. The Regional Monitoring Network is designed so that when examined as a group of E-Samplers working together, each site provides an important component for understanding the regional air quality and the overall effect of the WDMP activities. By developing a monitoring network with increased spatial distribution and sampling frequency Chu Cho Environmental has created more opportunities to probe and use the data to address the key management question and to provide insight into the effectiveness of WDMP operations.

Figure 1 shows the location of the 18 dust monitoring and 8 meteorology monitoring stations within the Finlay Arm of the Williston Reservoir.

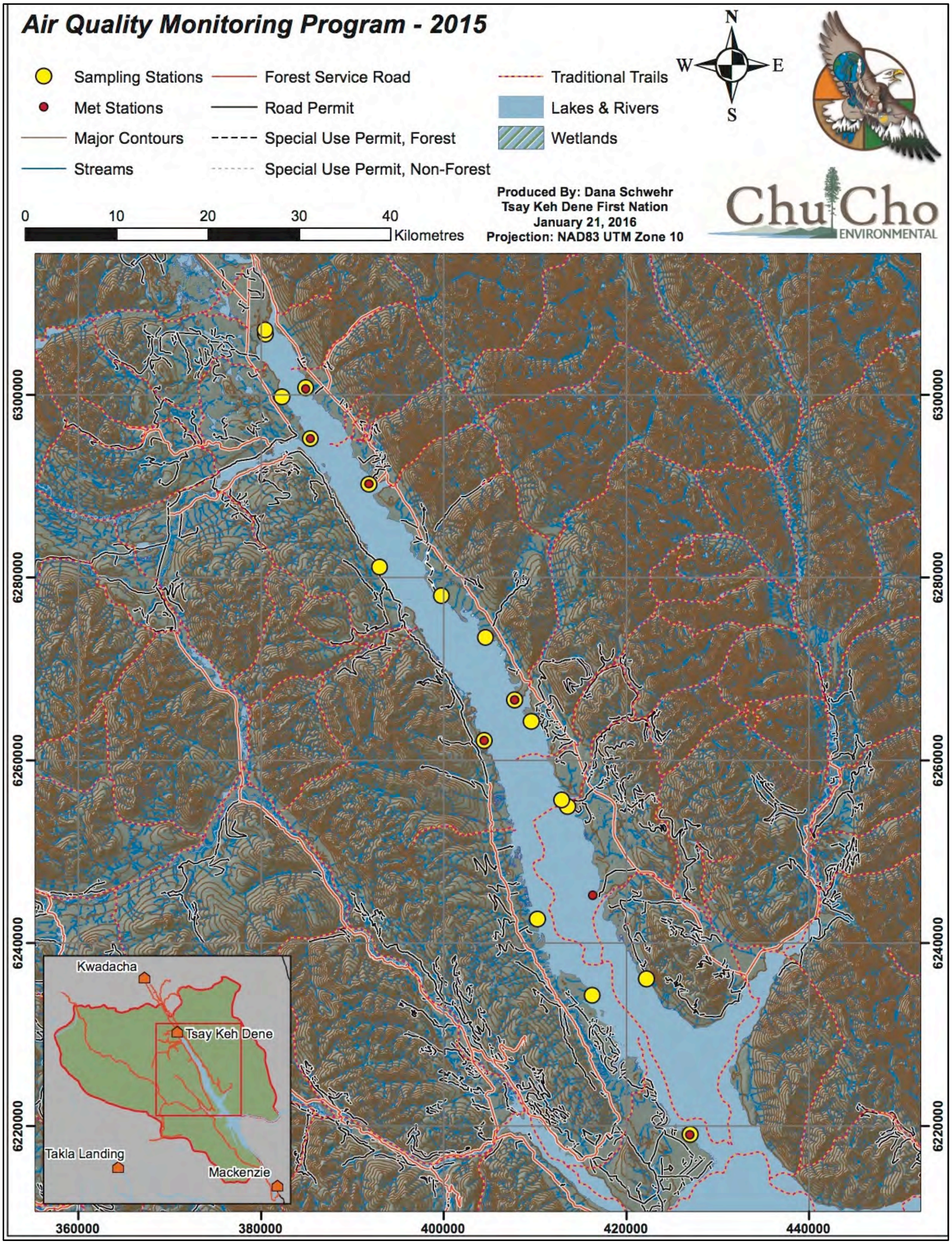


**Figure 1: Map of Regional Monitoring Network Sampling Locations**

### 2.1.1 DETAILED SITE DESCRIPTIONS

Table 2 provides a detailed overview of the monitoring station site locations, the instrumentation included and the type of airshed representation that the site provides:

**Table 4: Regional Monitoring Network Site Descriptions and Locations**

| Site Name | Lat | Lon | Met Station | Site Description | Airshed Representation | Instrumentation |
|---|---|---|---|---|---|---|
| Tsay Keh Village | 56.892 | -124.964 | Tsay Keh Village | The E-Sampler is Tsay Keh Dene is located on top of the TEOM Monitoring Station and is meant to collect data that is to be compared to the TEOM 1405-D. For 2015, we have added an additional E-Sampler in TKD that is located adjacent to the Tsay Keh Beach, which is a known high emitter. | Regional | E-Sampler, Met Station |
| Van Somer | 56.837 | -124.886 | Van Somer | Van Somer point is primarily comprised of Sandy Loam type sediment and is a known high emitter beach. This beach tends to hold tillage quite well because the increased clay content tends to hold moisture. The sample site is located on a gravel bar above the beach that is well exposed to southerly and northerly winds. The sampling equipment is well positioned to capture some local dust but also much of the regional dust passing by the area. | Regional /Local Dust | E-Sampler, Met Station |
| Tsay Keh Beach | 56.888 | -124.96 | Tsay Keh Village | Tsay Keh Beach is located at the northern tip of the Finlay Arm where the Finlay River meets the Williston Reservoir. Tsay Keh Beach is comprised of highly mobile sediments and is considered a beach with high emission potential (Nickling et al. 2012). An E-Sampler was placed in the foreshore zone of this beach in 2015 in order to capture the emissions from Tsay Keh Beach | Local | E-Sampler |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | prior to entering the village. | | |
| Chowika | 56.743 | -124.769 | Chowika | The Chowika monitoring station rests on a large gravel bar that extends far into the reservoir. This is very exposed to northerly and southerly winds and captures much of the fugitive dust from southern beaches that migrates towards TK village. This site produces no local dust emissions. | Regional Dust | E-Sampler, Met Station |
| Middle Creek North (MCN) | 56.634 | -124.640 | Chowika | MCN Beach is an exposed sand sheet and a high elevation beach. This beach is usually first to be exposed in the spring and the last one to be covered up by the reservoir. Large depositional and erosional sand features form on this highly mobile beach. This beach is considered a high emissions beach. This site has excellent exposure to southerly winds and moderate exposure to northerly winds. This beach was not tilled in 2015. | Local Dust | E-Sampler |
| Shovel | 56.599 | -124.563 | Davis South | Shovel beach is a mixed sand/silt/clay type beach that is regarded as a high emitter with many local hot spots. The mixed sediments on this beach tend to create clusters of sparse vegetation. There are numerous anecdotal accounts indicating that this beach regularly emits high amounts of fugitive dust. This site has excellent exposure to southerly winds and moderate exposure to northerly winds. | Local Dust | E-Sampler |
| Davis North | 56.535 | -124.497 | Davis South | Davis North Beach is a massive mixed sediment type beach that is considered a high fugitive dust emitter. The sampling equipment is well exposed to both northerly and southerly winds. | Local Dust | E-Sampler |
| Davis South | 56.514 | -124.469 | Davis South | Davis South Beach is a mixed sediment type beach that is known | Regional /Local | E-Sampler, |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | to emit large volumes of fugitive dust. Very large wet areas make fording and tilling the beach difficult. The sampling equipment is located in a clearing above a gravel bar that is above the reservoir full-pool level. This site is well exposed to southerly winds and is not exposed to northerly winds. | Dust | Met Station |
| Bruin Beach | 56.437 | -124.411 | Collins | Bruin beach is primarily composed of mixed sand and gravel and is considered a moderate emitter. The E-Sampler is located on a gravel point that is exceptionally well exposed to Southerly and Northerly winds. This site is well positioned to provide a regional evaluation in this area. | Regional | E-Sampler |
| Collins Beach | 56.427 | -124.393 | Collins | Collins beach is a mixed gravel/sand/silt beach that extends from Collins Bay to Lafferty. This beach has limited vegetation at higher elevations and is a known high emitter. The sampling equipment is located on a gravel bar approximately 500m south of the beach access point from Camp Collins. The equipment is well exposed to southerly winds and is moderately exposed to northerly winds. | Local | E-Sampler, Met Station |
| Lafferty | 56.344 | -124.354 | Lafferty | The sampling equipment at Lafferty sits on a large gravel bar that divides the very low elevation sections of the beach from the higher embayments. Some of the higher beach zones will generate vegetative growth while the lower sections are quickly covered up by reservoir water. The northern part of this beach is generally called Collins South and is known to be wet and full of root wads, stumps and deadheads. This site is exceptionally well exposed to | Regional Dust | Met Station |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | northerly and southerly winds. | | |
| Moody | 56.263 | -124.255 | Lafferty | The E-Sampler at Moody sits on a high gravel bar above the beach. The beach itself is comprised of mixed sands and silt. This site is exceptionally well exposed to southerly winds and captures early season dust storms from the low elevation Ospika Island Beach that is covered by the reservoir early in the season. | Regional Dust | E-Sampler |
| Rat Lake | 56.827 | -124.928 | Ingenika | The E-Sampler is located on a high reservoir cutbank approximately 20 meters above reservoir full-pool level. This site is exceptionally well exposed to southerly winds and moderately exposed to northerly winds. No dust is generated locally and this site provides adequate regional representation. | Regional Dust | E-Sampler |
| Ingenika Point | 56.700 | -124.800 | Ingenika | The sampling equipment is located on a rock outcrop on the northwestern corner where the Ingenika Arm and Finlay Arms intersect. This site is exceptionally well exposed to southerly, northerly and westerly winds and provides a regional representation of dust events that arrive at the old village location. No dust is produced locally here. | Regional Dust | E-Sampler, Met Station |
| 83km | 56.662 | -124.746 | Stromquist | The E-Sampler is located on a high reservoir cut bank approximately 20 meters above the reservoir full-pool level. The equipment is located on an old reservoir adjacent road. In 2009 the road was pushed back into the woods away from the reservoir and this site is located on what remains of the old road. This site is well exposed to Southerly winds and provides regional representation. No dust is generated locally and this site provides adequate regional | Regional Dust | E-Sampler |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | representation. | | |
| Stromquist | 56.567 | -124.628 | Stromquist | Sampling at this site was discontinued for 2015. | Regional | E-Sampler, Met Station |
| 57km | 56.494 | -124.552 | 35km | This site is named after the road kilometer where the access point is located. This site is located approximately 3km north of the Ole Creek beach and is not included as part of the mitigation program due to its small size. The beach is comprised of highly mobile sand/silt sediments and is a moderate emitter of fugitive dust. The site is well exposed to northerly and southerly winds and captures much of the sediment laden air plumes that drift north from the coreless complex. | Regional /Local Dust | E-Sampler |
| 35km (Lorimer) | 56.321 | -124.457 | 35km | This site is located adjacent to Lorimer Creek and near Pete Toy Creek and is situated on the beach known as Coreless F. The beach is comprised of very fine mostly silt based sediments and is a very high emitter. The sampling equipment is well exposed to both southerly and northerly winds. No vegetation was found on this beach. Based on the 2014 results this beach was not tilled in 2015. Unfortunately the water level was higher than usual in 2015 and so this site was only deployed for a total of 3 weeks at the end of May. | Local Dust | E-Sampler, Met Station |
| 25km (Chunamon) | 56.244 | -124.353 | Omineca | This site is located on the north shore of the Chunamon Creek embayment. In the area local to the E-Sampler there are mobile sediments but this site is generally marked with large vegetative islands. This site is well exposed to both northerly and southerly winds. | Local/Regional Dust | E-Sampler |

| | | | | | | |
|---|---|---|---|---|---|---|
| Omineca | 56.105 | -124.160 | Omineca | This sample site is located near the center of Omineca Beach and is exceptionally well exposed to both northerly and southerly winds. Omineca beach is a mixed sand/silt/clay beach and is known a high emitter of fugitive dust. Mixed sparse vegetation tends to grow in the vicinity of the sampling equipment. | Local Dust | E-Sampler, Met Station |

The following group of images shows each sample location from two perspectives:


**Figure 2: Middle Creek North Regional Monitoring Network**

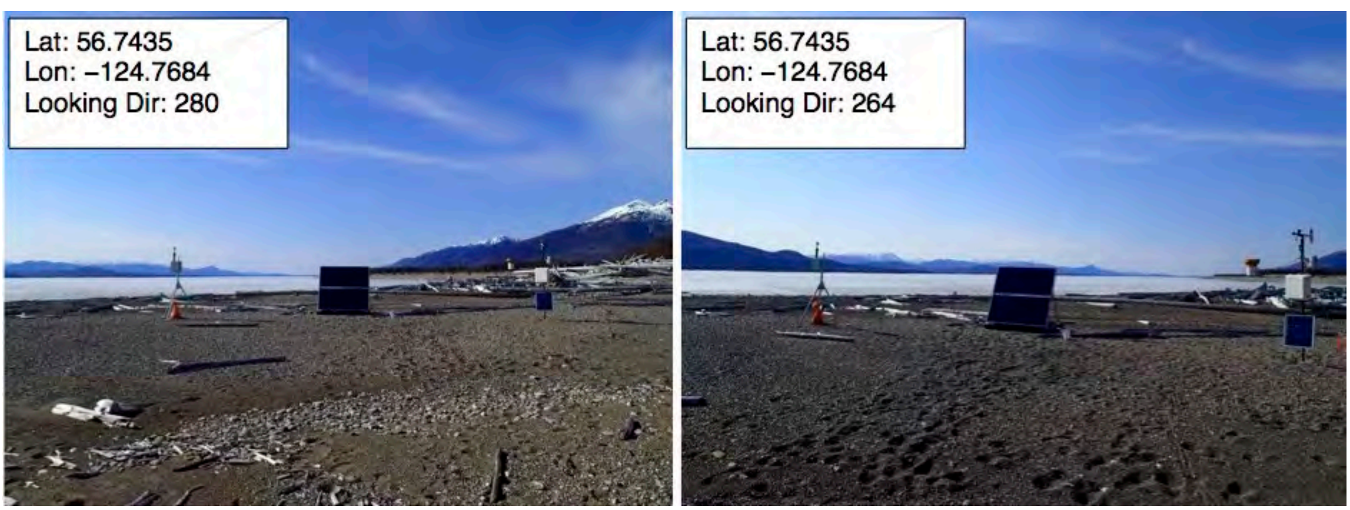


**Figure 3: Chowika Regional Monitoring Network**

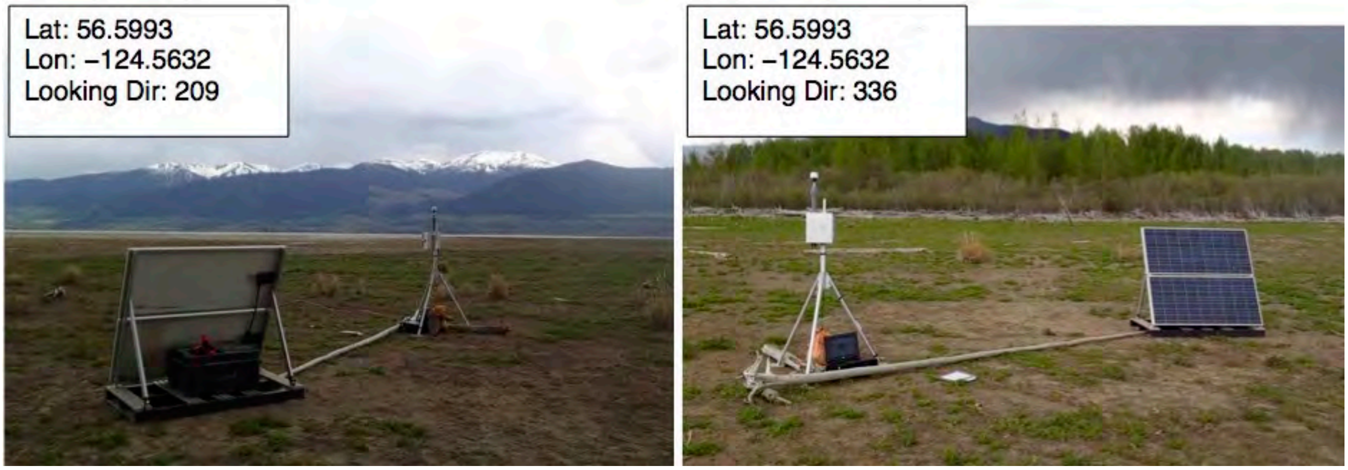


**Figure 4: Shovel Regional Monitoring Network**


**Figure 5: 25Km Regional Monitoring Network**

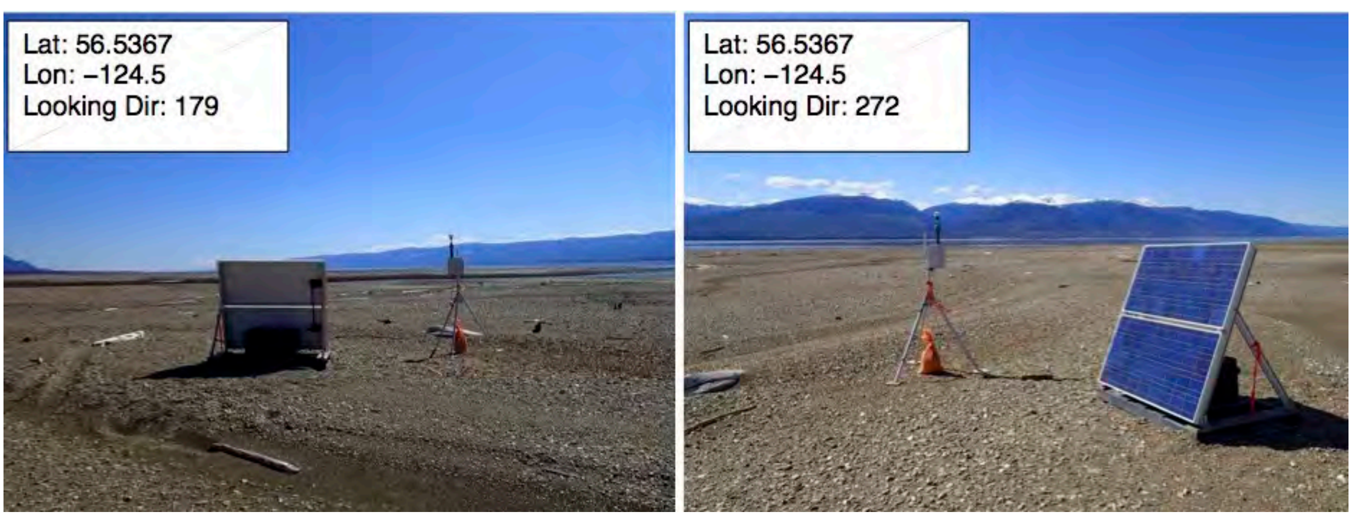


**Figure 6: Bruin Regional Monitoring Network**


**Figure 7: Moody Regional Monitoring Network**


**Figure 8: 83Km Regional Monitoring Network**


**Figure 9: Davis North Regional Monitoring Network**


**Figure 10: Rat Lake Regional Monitoring Network**

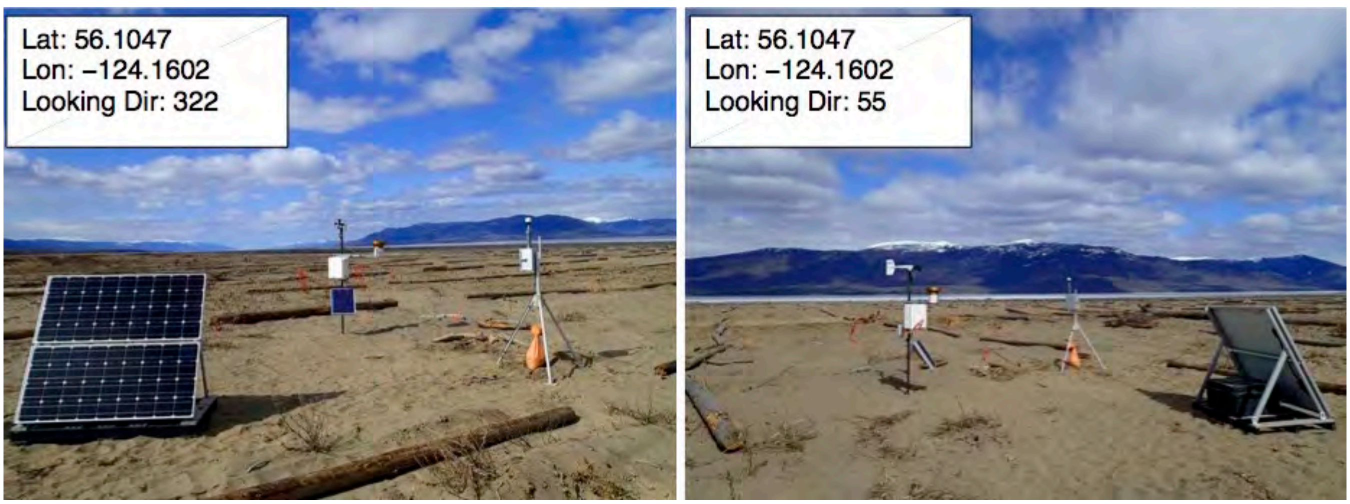


**Figure 11: Omenica Regional Monitoring Network**


**Figure 12: Davis South Regional Monitoring Network**


**Figure 13: Tsay Keh Dene Regional Monitoring Network and Reference Station**


**Figure 14: 57Km Regional Monitoring Network**

**Figure 15: Collins Beach Regional Monitoring Network**


**Figure 16: Ingenika Point Regional Monitoring Network**


**Figure 17: Lafferty Regional Monitoring Network (2014 Photo – There are no dust samplers in 2015)**


**Figure 18: 35Km Regional Monitoring Network**

The remainder of Section 2.0 provides detailed information on the instrumentation, the analyses and the results obtained from the regional monitoring network.

### 2.1.2 Instrumentation

MetOne E-Samplers function according to a unique operating principle that employs laser backscatter to estimate the concentration of particulate in air at any given moment. Air is drawn into the E-Sampler at a constant velocity where it travels through a defined flow path and measurement chamber. A 690nm laser is shone across the flow chamber, through the particulate laden air where it is received by a light sensor on the opposite side of the chamber. When there are zero particles in the air stream, there is zero scatter of the laser beam and the light sensor responds accordingly. Where there are a number of particles in the air stream, there will be some scatter of the laser beam and the light sensor will record a reduced signal. The sensor therefore responds to the amount of light, which passes through the flow and the response is inversely proportional to the amount of particulate in the air stream.

The laser scatter method does not hold Federal Reference Method (FRM) or Federal Equivalent Method (FEM) designation but has been approved for fence-line type inter-comparison studies by the U.S. forest service. This means that E-Sampler data are not directly comparable to that collected by an FRM or FEM machine and cannot be used to evaluate CAAQS exceedences or non-compliance. However, they are very useful for dispersion modeling and for observing source/sink locations around the reservoir.

There is no standard protocol or NIST traceable method for calibrating and maintaining the E-Sampler since it does not carry FRM nor FEM designation. However, Chu Cho Environmental does employ a U.S. EPA quality program for monitoring and maintaining the function of the E-Sampler. This includes monthly flow calibration, leak check, filter cleaning and data validation.

## 2.2 Regional Monitoring Network Data Overview

E-Sampler data are read at 1Hz and are recorded at 5-minute average intervals. Data are collected from 18 instruments for the entire snow-free period (approximately May to October) in the Finlay Valley. During the 2015 sampling season the reservoir reached near full-pool levels in late June and peaked by August, this meant that many of the sampling sites that were left accessible in 2014 were not in 2015. As a result our project team had to remove each sampler sequentially over the month of July to avoid water inundation. The last sampler (Davis North) was taken down on August 7$^{th}$. There are 8 complete meteorology stations that are located at a subset of the 18 E-Sampler sites (Refer to Table 1 for the E-Sampler/Met Combo list). These stations read the instrumentation at 1Hz and record 5-minute average data for relative humidity, rainfall rate, air temperature, wind speed and wind direction. The regional monitoring network amasses an enormous volume of data very quickly and requires an aggregation of complex computer programming to handle and process. Data are managed primarily through Dropbox syncing and Matlab scripting.

This distributed network of continuously monitoring E-Samplers and weather stations has allowed us to probe dust events through avenues, which have not yet been investigated and also allows our team to create visuals that provide un-paralleled insight into the development, evolution and termination of dust events.

The analyses discussed in this report represent Chu Cho Environmental's initial perspective and current understanding of the air quality issues within the Finlay Valley. Following the presentation of our results a preliminary data review will be performed to uncover potential limitations of using the data, to reveal outliers and generally to explore the basic structure of the data. This review will begin with an exploration of the quality of the data through a basic statistical examination followed by an advanced statistical assessment using analysis of variance and regression.

### 2.2.1 Data Quality Objectives

For air monitoring networks, Data Quality Objectives (DQOs) are statements that document and specify the data quality criteria that must be satisfied in order to have adequate confidence in the conclusions of studies (CCME, 2011). Ultimately the DQOs are a series of statements that relate the quality of the measurements to the level of uncertainty that we are willing to accept for results derived from this data.

DQOs must have attributes that are both qualitative and quantitative and are generally defined as those measureable attributes of the monitoring data that will allow program objectives and measurement objectives to be met.

As is typical for most air quality monitoring networks even those of a non-regulatory nature we will adopt the following DQO attributes:

- Accuracy:
  - E-Samplers must be calibrated and maintained to sustain an accuracy of greater than +/- 20%. The project samplers are sent to MetOne Instruments for calibration every 18 months.
- Precision:
  - E-Samplers must be calibrated and maintained to sustain a precision that deviates less than 10% from a zero standard. This is done through an internal automated process within the E-Sampler and any errors that are detected are recorded and delivered to the user. This calibration process is completed monthly in the field.
- Completeness:
  - In order to be considered a valid data reading the E-Sampler must record data for greater than 75% of the available minutes within an hour. This means that in order to be considered a valid hour of data there must be at least 45 minutes of data recorded.
- Comparability:
  - We maintain a small subset of filter based monitoring instruments that are used to collect samples at random times for comparison to E-Sampler data. These data are

used to provide assurance that the E-Samplers are maintaining function through time.

- Averaging Period:
  - E-Sampler data are collected at 1Hz and are recorded as 5-minute averages to the on-board memory. These data are downloaded and verified once or twice per month.
- Measurement Cycle:
  - E-Sampler data is collected from April until October of each year. Data analysis is focused on the Period from April to June or what is typically called the dust season; this may be extended during particularly dry or low-water years.
- Spatial Representativeness:
  - The samplers are located in areas where they will not be influenced by external factors that may cause sample bias. This includes the following specifications:
    - Sampler intake height is more than 2 meters above the earth's surface.
    - Sampler is located a sufficient distance away from roadways and other sources of external contamination such as incinerators or factories.
    - Sampler intake is located a sufficient distance away from airflow restrictions through 360 degrees of rotation and must be located at a distance away from an object that is at least 3 times the height of that object.
    - Sampler intake is located greater than 20 meters away from trees.

Chu Cho Environmental ensures that suitable technical procedures are in place to record and catalog the processes that lead to successful achievement of the DQOs.

Since E-Samplers do not carry a Federal Reference Method designation we do not adhere to a national or international traceable standard (e.g. NIST) for auditing procedures. However, we do utilize a TSI flow meter and record keeping standards that are of NIST quality to ensure that our network data is internally comparable.

### 2.2.2 Time Series Analysis

Data collected by the Regional Monitoring Network shows a variety of dust event types throughout the typical April – June dust season ranging in magnitude from small scale isolated occurrences that last less than 30 minutes to large scale valley wide events that may last more than 24 hours. In 2014 the Regional Monitoring Network recorded a number of long-duration valley-wide events, but there were no similar events recorded in 2015. In general 2015 was a very low-wind, low-dust year when compared to the previous 7 years.

Figure 19 contains a time series depiction of the E-Sampler data collected at four locations in the Regional Monitoring Network. The remaining 14 E-Sampler time series graphs are located in Appendix A. Each of the plots in Figure 19 features the time series TSP data read by each instrument. The data shown on these charts are unprocessed raw data that represent the 5-minute average being recorded by the instrument.

We see that there are several relatively high magnitude but short duration TSP peaks throughout the typical dust season. It is also apparent that the E-Samplers are regularily recording a considerable amount of low-level background ambient particulate matter in the airshed.

**Threshold:**

Over the years much of the discussion surrounding dust events in the Finlay Valley has focused on threshold wind speeds for initiating sediment movement. The high temporal resolution of the E-Samplers means that we are able to capture more events of varying magnitude at relatively high frequency, however not all the activity recorded by an E-Sampler should be considered a dust event – We will define what constitutes a dust event in the following paragraphs.

There are microbursts and convective air movements, which could cause the E-Sampler to register particulate matter. These are not the event types we wish to analyze. In order to qualify as a dust event, the E-Sampler must register an average value that is above the threshold for at least 30 minutes.

Since E-Samplers are not FRM/FEM certified instruments there is no numerical standard by which to define a dust event. For this project we developed a subjective means for defining a dust event using images captured by the network of time-lapse cameras. The threshold value is determined by comparing images captured during periods of no dust to those captured during periods of increasing dust. The relative ocular obscurity is proportional to the volume of dust in the air. By repeating this exercise for numerous dust events across numerous sites we are able to arrive at a value that our project team feels is a reasonable approximation for a threshold dust value. We used a number of replicate sites for this exercise (Middle Creek North, Shovel Creek, Van Somer, 35km, Ingenika and Davis North) and arrived at a value of 0.1 $mg/m^3$ TSP as the E-Sampler threshold for dust events. Since there are microbursts that result in a reading of 0.1 $mg/m^3$ we have established 30 minutes or 6 consecutive 5-minute average readings as the time duration over which the threshold concentration must persist in order to be classified as a dust event.

Therefore, in order to be considered a dust event the average reading must exceed 0.1 $mg/m^3$ TSP for 30 minutes or more. A drop in the average reading below the threshold for 20 minutes or more signals the end of a dust event. This means that there could be numerous dust events registered in a single day that meet the criteria and in our analysis these are considered discrete events. Since E-Sampler data are not compared with Federal CCME guidelines or Provincial AQOs we have not reduced these data to 24hr averages. Note that this inferred threshold value is a conservative value so that we truly avoid flagging false positives. In the following section, each reference to a dust event or a number of dust events indicates that the data have met the above criteria.

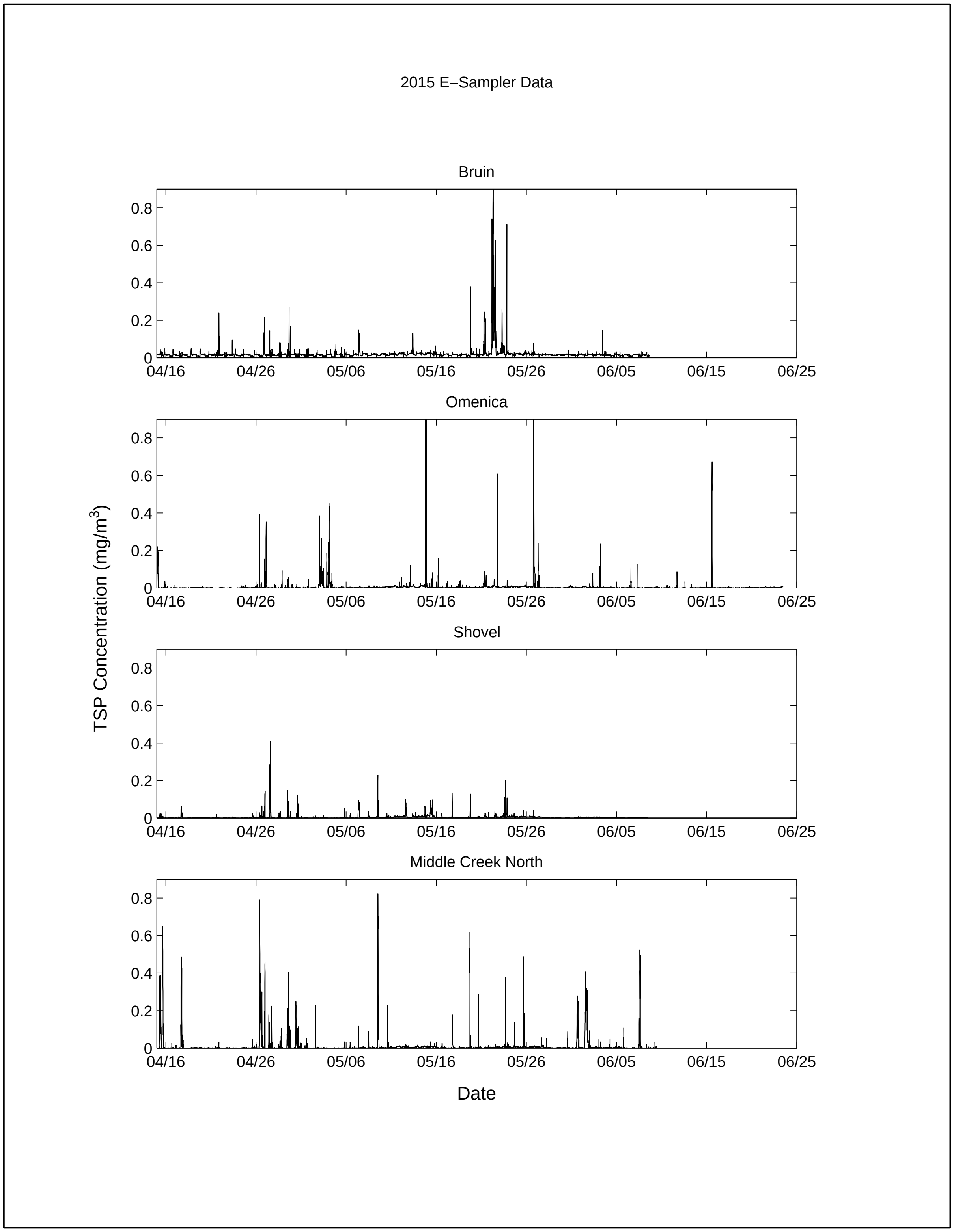


**Figure 19: Sample of Regional E-Sampler Data from 4 Locations – Showing 5 minute average data.**

## Statistical Analysis:

Basic descriptive parameters were extracted from the time series data collected at each location over the duration dust season. These data are summarized in Table 5 and Table 6 on the following pages. We have chosen to leave the 2014 summary table in this report to make inter-year comparison easier. It should be noted that the 2014 season was 48 days long while the 2015 season was 71 (April 15th – June 25th) days. This is because our team deployed the instruments by the first week of April and also because the snowpack disappeared rapidly in 2015 exposing the beaches by the middle of April. Ultimately this means that there were more events recorded in 2015 than 2014. 35km is an exception here because it was not deployed until May 25th, 2015 and was demobilized on June 9th, 2015 due to reservoir levels.

At Middle Creek North (MCN) there were 266 recorded dust events at an average TSP concentration of 0.25 mg/m$^3$. The average wind speed during these events was 5.2 m/s while the maximum recorded wind was 11.4 m/s.

In general, the average concentration of TSP and average wind speed during dust events in 2015 were smaller than the 2014 values but the difference has not been analyzed statistically. Max wind speed and threshold wind speed appear to be similar in magnitude between sites and years.

As our project team collects additional summary data for the Regional Monitoring Network we will begin to expand this data looking for site specific trends and trends as the TSP data relate to meteorology data.

It should be noted that the 2015 data collected at the Chowika monitoring station was suspect and has undergone rigorous inspection and data verification. It appears that subtle power surges/dips from a faulty solar controller were causing the datalogger to record anomalous values. We have flagged and removed all inconsistent and inaccurate data from the Chowika dataset and have only analyzed the remaining good data.

The data presented below were extracted using the threshold criteria described above and are reported within the context of our definition of dust events. For example, the column marked % of Time with Dust Above Threshold represents the percentage of the total time that the sampler was reading above the threshold value.

**Table 5: 2015 Dust Season Dust Event Summary Statistics – Statistical data calculated using the 5-minute average data.**

| Site ID | # of Dust Events | TSP Conc. (mg/m$^3$) | % Time With Dust Above Thres | Avg. Wind Speed (m/s) | Max Wind Speed (m/s) | Min Wind Speed (m/s) | Threshold Wind Speed (m/s) | Threshold Wind Spd. Std. Dev. (m/s) | Avg. Wind Dir (deg) | Std Dev. Wind Dir (deg) |
|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | hold | | | | | | | |
| MCN | 266 | 0.25 | 0.41 | 5.2 | 11.4 | 1.1 | 5.2 | 1.9 | 186 | 59 |
| Shovel | 21 | 0.17 | 0.03 | 5.3 | 9.2 | 1.5 | 5.3 | 2.1 | 147 | 67 |
| Chowika | 61 | 0.55 | 0.09 | 2.4 | 7.5 | 1 | 2.4 | 1.2 | 238 | 67 |
| 25km | 19 | 0.16 | 0.03 | 2 | 5.4 | 0.4 | 2 | 1.4 | 147 | 104 |
| 35km | 78 | 0.39 | 0.12 | 4.6 | 6.9 | 0.8 | 4.6 | 1.2 | 161 | 168 |
| Moody | 4 | 0.38 | 0.01 | 0.1 | 0.2 | 0 | 0.1 | 0.1 | 144 | 45 |
| 83km | 30 | 0.21 | 0.05 | 3 | 11.2 | 0.1 | 3 | 4.1 | 142 | 122 |
| Davis N. | 23 | 0.22 | 0.04 | 7.6 | 11.2 | 4 | 7.6 | 1.3 | 325 | 37 |
| Tsay Keh Beach | 201 | 0.26 | 0.31 | 2.4 | 5.7 | 0 | 2.4 | 1.7 | 253 | 94 |
| Rat Lake | 21 | 0.35 | 0.03 | 7.4 | 13.3 | 1 | 7.4 | 4.9 | 125 | 94 |
| Omineca | 130 | 0.52 | 0.2 | 2.8 | 7.5 | 0.3 | 2.8 | 1.6 | 143 | 96 |
| Davis S. | 8 | 0.13 | 0.01 | 5.1 | 7.9 | 1.2 | 5.1 | 3 | 197 | 150 |
| Van Somer | 28 | 0.15 | 0.04 | 4.3 | 5.7 | 0.7 | 4.3 | 1.2 | 139 | 50 |
| Tsay Keh Town | 25 | 0.14 | 0.24 | 1.3 | 5.3 | 0 | 1.3 | 1 | 185 | 62 |
| 57km | 28 | 0.23 | 0.04 | 2.6 | 6.1 | 0.4 | 2.6 | 1.6 | 254 | 83 |
| Ingenika | 2 | 0.12 | 0 | 0 | 0.1 | 0 | 0 | 0.1 | 49 | 69 |
| Lafferty | 4 | 0.15 | 0.01 | 1.3 | 1.4 | 0.9 | 1.3 | 0.3 | 159 | 108 |
| Collins | 5 | 0.26 | 0.01 | 1.2 | 1.4 | 0.8 | 1.2 | 0.3 | 170 | 97 |
| Bruin | 113 | 0.28 | 0.17 | 1.2 | 9.2 | 0.1 | 1.2 | 1.6 | 234 | 105 |
| **Averages** | **56** | **0.3** | **0.1** | **3.1** | **6.7** | **0.8** | **3.1** | **1.6** | **179** | **88** |

**Table 6: 2014 Dust Season Dust Event Summary Statistics – Statistical data calculated using the 5-minute average data.**

| Site ID | # of Dust Events | TSP Conc. (mg/m³) | % Time With Dust | Avg. Wind Speed (m/s) | Max Wind Speed (m/s) | Min Wind Speed (m/s) | Threshold Wind Speed (m/s) | Threshold Wind Spd. Std. Dev. (m/s) | Avg. Wind Dir (deg) | Std Dev. Wind Dir (deg) |
|---|---|---|---|---|---|---|---|---|---|---|
| MCN | 73 | 0.31 | 3.53 | 7.5 | 13.4 | 0.3 | 6.1 | 2.6 | 171 | 76 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Shovel | 48 | 0.21 | 1.03 | 5.5 | 9.3 | 0.5 | 4.6 | 2 | 171 | 59 |
| Chowika | 6 | 0.14 | 0.04 | 9.7 | 13 | 4.6 | 9.7 | 3.2 | 188 | 147 |
| 25Km | 25 | 0.21 | 0.91 | 3 | 3.4 | 2.8 | 3.1 | 0.4 | 128 | 165 |
| 35Km | 108 | 0.59 | 4.23 | 6.5 | 11.6 | 0.9 | 4.7 | 1.8 | 199 | 125 |
| Moody | 5 | 0.14 | 0.12 | 11.4 | 12.7 | 9.3 | 10.2 | 0.5 | 330 | 6 |
| 83Km | 14 | 0.25 | 0.25 | 2 | 4.3 | 0.3 | 2 | 1.4 | 200 | 78 |
| Davis North | 33 | 0.44 | 1.78 | 3.5 | 14.1 | 0.6 | 4 | 3.4 | 124 | 100 |
| Rat Lake | 15 | 0.31 | 0.31 | 7.6 | 11.1 | 0.9 | 7.3 | 3.1 | 174 | 57 |
| Omenica | 28 | 0.30 | 1.27 | 3.3 | 5.2 | 0.8 | 2.6 | 1.5 | 115 | 103 |
| Davis South | 23 | 0.22 | 0.81 | 4.7 | 9.7 | 1.1 | 5.7 | 3.1 | 121 | 86 |
| Van Somer | 23 | 0.19 | 0.31 | 7.7 | 11.3 | 2.5 | 6.7 | 2.9 | 226 | 89 |
| Tsay Keh | 23 | 0.15 | 0.59 | 9.3 | 11.5 | 2.3 | 8.6 | 2 | 128 | 17 |
| 57Km | 41 | 0.26 | 1.66 | 5.8 | 9.8 | 0.6 | 4.3 | 2.1 | 251 | 134 |
| Ingenika | 7 | 0.13 | 0.08 | 4.6 | 10.9 | 0.3 | 5.6 | 4.8 | 205 | 68 |
| Lafferty | 14 | 0.22 | 0.88 | 9.5 | 12.7 | 2.7 | 8.2 | 2.2 | 206 | 81 |
| Collins | 5 | 0.13 | 0.04 | 9 | 10.3 | 5.9 | 8.7 | 1.7 | 170 | 39 |
| Bruin | 49 | 0.30 | 1.85 | 8.4 | 13 | 1 | 7.2 | 2.4 | 242 | 88 |
| Stromquist | 11 | 0.18 | 0.31 | 2.1 | 6.3 | 0.6 | 2.1 | 2 | 191 | 71 |
| **Average** | **29** | **0.25** | **1.05** | **6.4** | **10.2** | **2.0** | **5.9** | **2.3** | **186** | **84** |

**Number of Dust Events:**

Samplers on Middle Creek North and Shovel Creek receive large quantities of fugitive dust due the high wind exposure and proximity to mobile sediments. Using our estimated threshold of 0.1 mg/m$^3$ for TSP, the E-Samplers at Middle Creek North and Shovel recorded 73 and 48 dust events during the 48-day 2014 dust season and 266 and 21 during the 71-day 2015 dust season. This means that there are multiple periods within a single day that fit the criteria for being classified as a dust event. Ingenika on the other hand recorded only 7 events in 2014 and 2 in 2015, but is located far away from any dust source on a rock outcrop that extends into the reservoir. 35Km recorded 108 dust events in 2014 and 78 in 2015 (in only 20-days), this is likely the result of highly localized wind activity and the presence of highly mobile silt and clay at the sample site.

Viewing the data through this lens allows us to examine our dataset for localized "hotspot" zones such as Middle Creek North, and then evaluate the downwind effects of hotspots on more remote sites such as Ingenika or Chowika. We utilize this approach to determine to what extent the "hotspot" beaches are contributing to downwind dust concentrations and under what environmental conditions they proliferate.

The average number of dust events in 2014 as defined above across all sample locations throughout the dust season was 29, which is equivalent to approximately 1.05% of the total time that the instruments were recording. In 2015 the average number of dust events increased to 56 but the total percentage of time that the samplers were recording dust decreased dramatically to 0.1%. This indicates that many of the dust events were likely very short-lived microburst type dust events that were large enough in magnitude to meet the threshold criteria but were relatively short in duration.

**Wind Speed and Wind Threshold:**

The average wind speed during dust events was calculated as 3.1 m/s in 2015 down from 6.4 m/s in 2014. This is representative of the overall 2015 dust season dataset and speaks to the observed reduction in average TSP concentrations at most sites. There were a number of locations where *low* localized wind speeds were associated with dust events, these include: Middle Creek North, Shovel Creek, Stromquist, 83Km, Davis North, 57Km, Ingenika Point, and 35Km. These sites represent the full range of site types from gravel bars and wetted zones to highly emissive sand sheets. This type of data strongly indicates that TSP may travel from the source beach to other areas of the reservoir. The migration of dust from source locations throughout the reservoir is discussed in detail in Section 2.2.4 Dust Event Type Heatmap Analysis.

The average threshold wind speed for dust events was calculated by extracting the wind speed data leading up to the point in time when the event threshold of 0.1 $mg/m^3$ TSP was surpassed and averaging the previous 30 minutes of data. The average wind speed threshold for all dust samplers was calculated at 5.9 m/s in 2014 and 3.1 m/s in 2015. Again this reduction is characteristic of the 2015 dataset and the generally mild wind conditions present during the dust season. Some sites such as 35Km show lower wind threshold values because the local beach sediments are highly erodible and therefore emit dust at lower wind speeds. It is well known that the movement of highly mobile and loosely consolidated sediments (such as those found on many beaches in the Finlay Arm of the Williston reservoir) is initiated proportionally with respect to wind speed for a given sediment size distribution (Nickling, 1988). Other sample sites such as 83Km and Ingenika also show lower than average dust event wind speed threshold, even though the sites are located where no dust is produced. The dust usually arrives at these sites within a few hours following an event at one of the more emissive sites further upwind. This reaffirms our observation that TSP tends to drift very long distances from source areas to samplers located in non-producing areas.

**Wind Direction:**

There is a great deal of variability within the average wind direction between many of the sample sites, however the dominant wind direction typically contains a southerly component but might vary from Southwest to Southeast. Many of the sites will generally respond to either Northwest or Southeast winds, which have been identified as the dominant wind directions in this part of the Finlay Valley (Nickling et al. 2013). To some extent the dominant wind direction value is influenced by some of the unavoidable compromises (such as site access) that must be made during our site selection. We do strive to avoid placing sites where the influence of local geography and vegetation will affect the wind readings.

### 2.2.3 BGI PQ200 Air Quality Samplers

The use of BGI PQ200's was discontinued for 2015. It was determined that the data collected by the PQ200's is not of high enough temporal or spatial resolution to functionally address the key management question and that the labor costs associated with maintaining these instruments is prohibitively high. Chu Cho Environmental decided that it would be prudent to spend project resources on improving the reliability, accuracy and precision of the E-Sampler monitoring network.

Initially it was planned that the data collected by these instruments would provide an independent verification for the co-located E-Sampler. However, the BGI PQ200s are built to collect $PM_{10}$ and $PM_{2.5}$ sized particles while the E-Samplers were setup to collect TSP. These measurement values are fundamentally different and are not directly comparable.

Ultimately, the BGI PQ200s are an excellent instrument but their use in the regional monitoring network is not well founded. The purpose of the regional monitoring network is to address the GMSMON#18 key management question. By sampling on either a random or a 1-in-6-day schedule the BGI PQ200s are bound to miss dust events and therefore are unable to address the key management question. The BGI PQ200s are a reference monitor and if used at regular intervals over a long enough time period, can begin to provide insight into baseline air quality issues. This is the primary use of the instrument.

Moving forward, in 2016 our project team will maintain 2 BGI PQ200's located in Tsay Keh Dene in order to provide FRM reference monitoring verification for the TEOM 1405-D monitoring unit.

### 2.2.4 Dust Event & Occurrence Type Heatmap Analysis

The images presented over the next several pages (Figures 20 - 25) were created using an analysis called heatmap interpolation that was applied to the Regional Monitoring Network data. This process uses nearest neighbor triangulation to create a high density array of coloured triangles where the greatest "heat," or in our case dust, is indicated by deep red, and the least dust is indicated by dark blue.

The heatmap interpolation is performed across the entire 18 E-Sampler/8 Met Station dataset for every 5-minute interval. The result is a time series of spatial data and images that show where the greatest concentration of dust is at any given 5-minute interval within the Finlay Valley. This perspective has truly revolutionized our thinking surrounding dust events in the reservoir. Namely, it was widely accepted that dust events occur at relatively infrequent intervals, usually on a large scale. This analysis has shown us that there are in some cases hundreds of events on a single beach throughout the dust season. These dust events range in size from small to large scale, and that some locations regularly emit much higher levels of dust than others. This conclusion, as reached through analysis of the heatmap data is consistent with the anecdotal observations provided by numerous people who have in some way worked on the dust mitigation project since 2008.

In order to fully appreciate this analysis we have created programming that enables us to observe these spatial heatmap images temporally by linking each image in time lapse. The result is a video, which can be sped-up or slowed down to view the initiation, development, evolution and dispersion of dust events in 5-minute time segments. The time-lapse videos are discussed in Section 2.2.5 Time Lapse Analysis.

Firstly we will examine 4 snapshots from the heatmap analysis for 3 different event types from the 2014 dust season. Our intention is to discuss the development of various dust events over time and it is apparent that the data collected in 2014 are well suited to this purpose. Figures 20 through 22 show three distinct types of dust event that were observed on several occasions throughout the dust season. Note that the arrows on the images point towards the direction winds are coming from and the length of the arrow is proportional to strength of the wind. All data shown below were calculated using the 5-minute average data recorded by the E-Samplers, therefore each image represents a 5-minute average data snapshot of the dust conditions surrounding the reservoir.

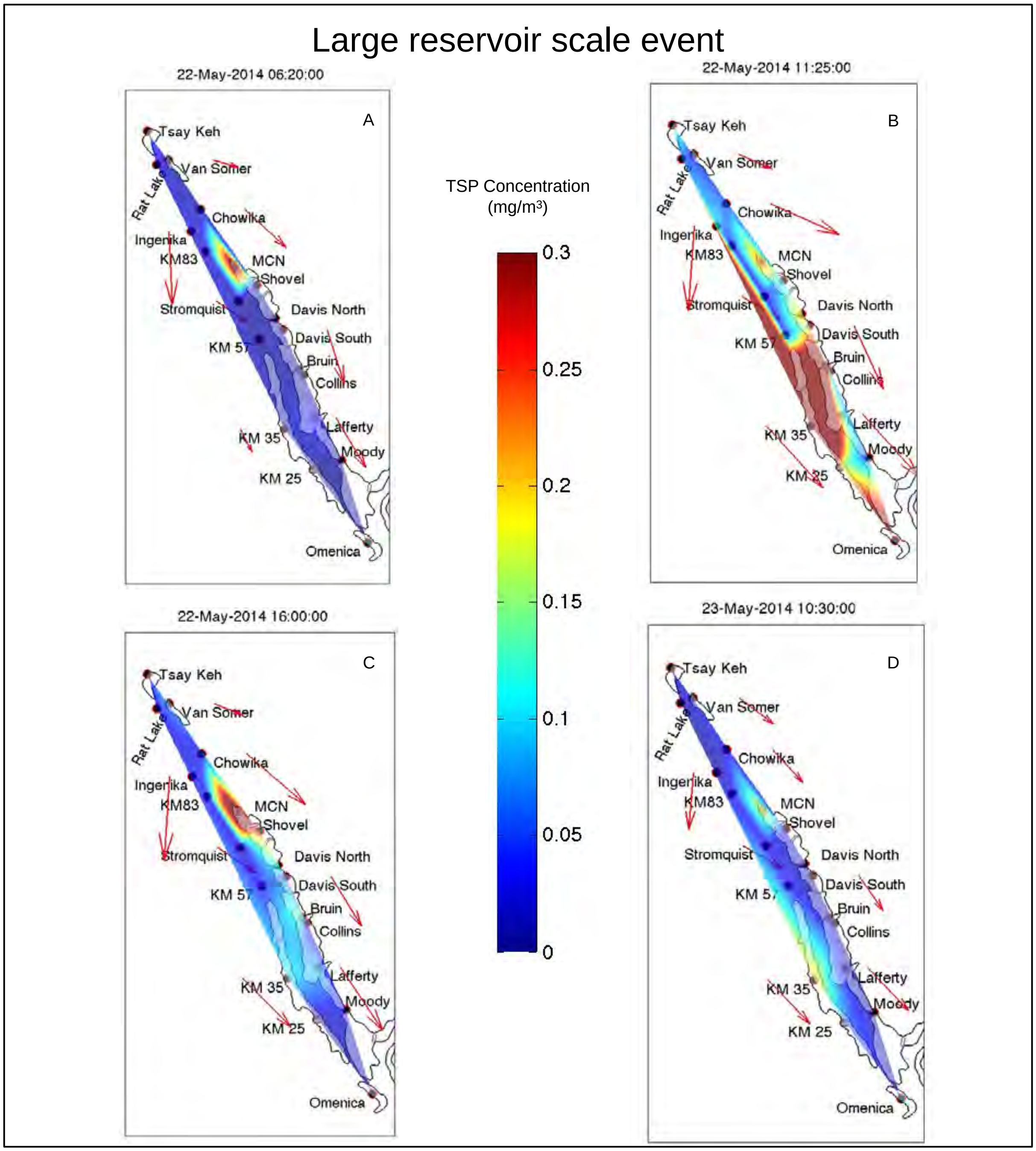


**Figure 20: Heatmap Analysis - Large Scale Event – Each plots shows an instantaneous snapshot of the 5-minute average data.**

## Large Scale Event:

Figure 20 contains four images, which show the development of a valley wide dust event. Figure 20 (A) shows the storm beginning near MCN at 06:20 on May 22nd, 2014 with winds from the south. 5 hours later, Figure 20 (B) shows how the storm has grown to fill the southern section of the Finlay

Valley. Figure 20 (C) shows that the storm took a brief hiatus near 16:00 (with the exception of the MCN area) but didn't completely subside until after 10:30 on May 23rd, 2014.

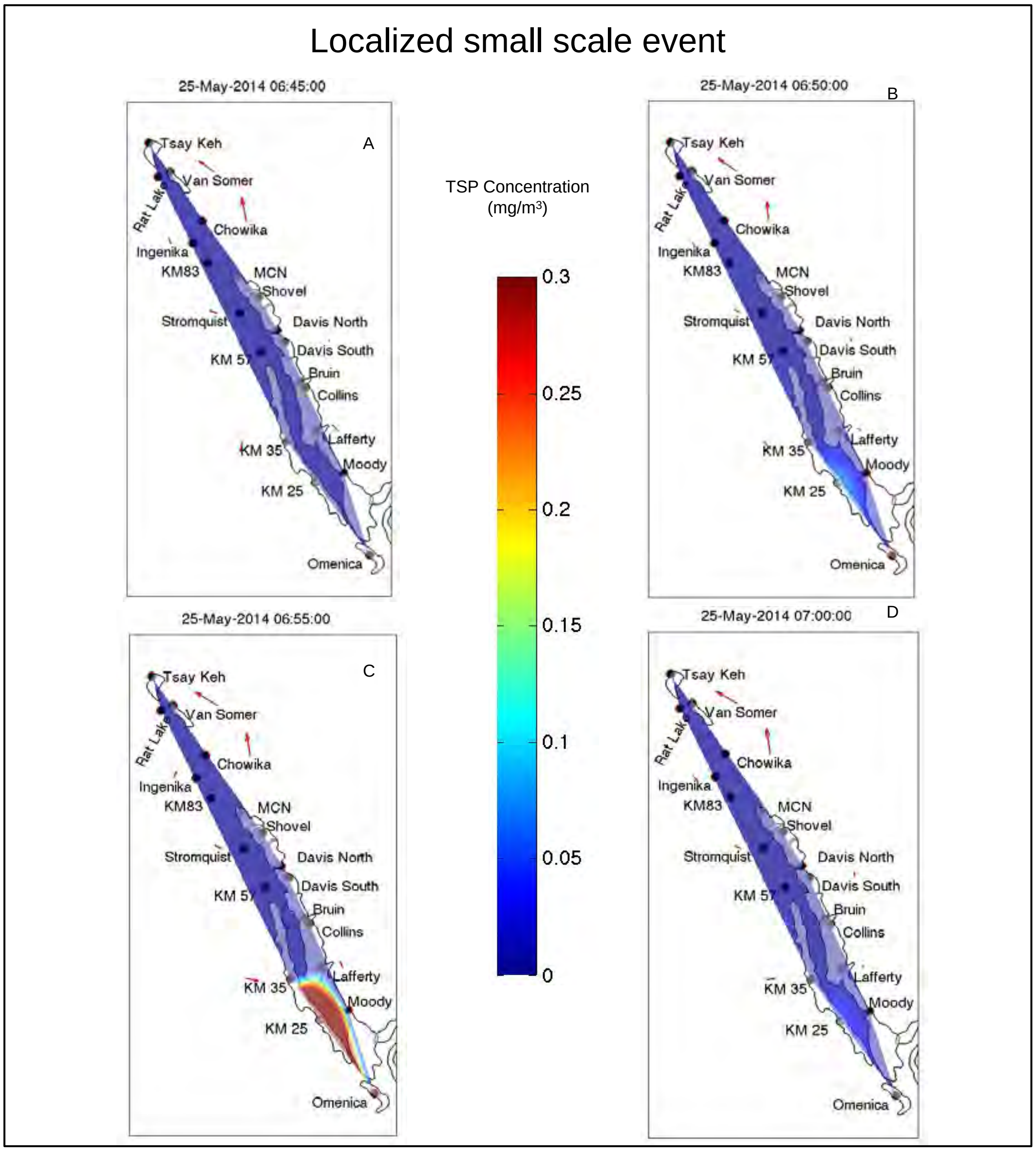


**Figure 21: Heatmap Analysis - Localized Occurrence – Each plots shows an instantaneous snapshot of the 5-minute average data.**

## Small Scale Occurrence:

Figure 21 contains four images, which show the development of a small occurrence localized to a single beach. Figure 21 (A) shows the Finlay Valley under pristine air quality conditions at 06:45 on May 25th, 2014. Figure 21 (B) shows the development of a small microburst at 25Km and 35Km starting at 06:50. At 06:55, the microburst has blown up to a very high concentration localized dust occerence (Figure 21 (C). Then at 07:00, Figure 21 (D) shows that the microburst dust occurrence has stopped and dissipated. This entire micro-occurrence took place over a 20-minute period and although this would not adversely affect the air quality in Tsay Keh Dene it is a prime example of the variability across the reservoir. This occurrence does not pass our threshold limit to be considered a dust event.

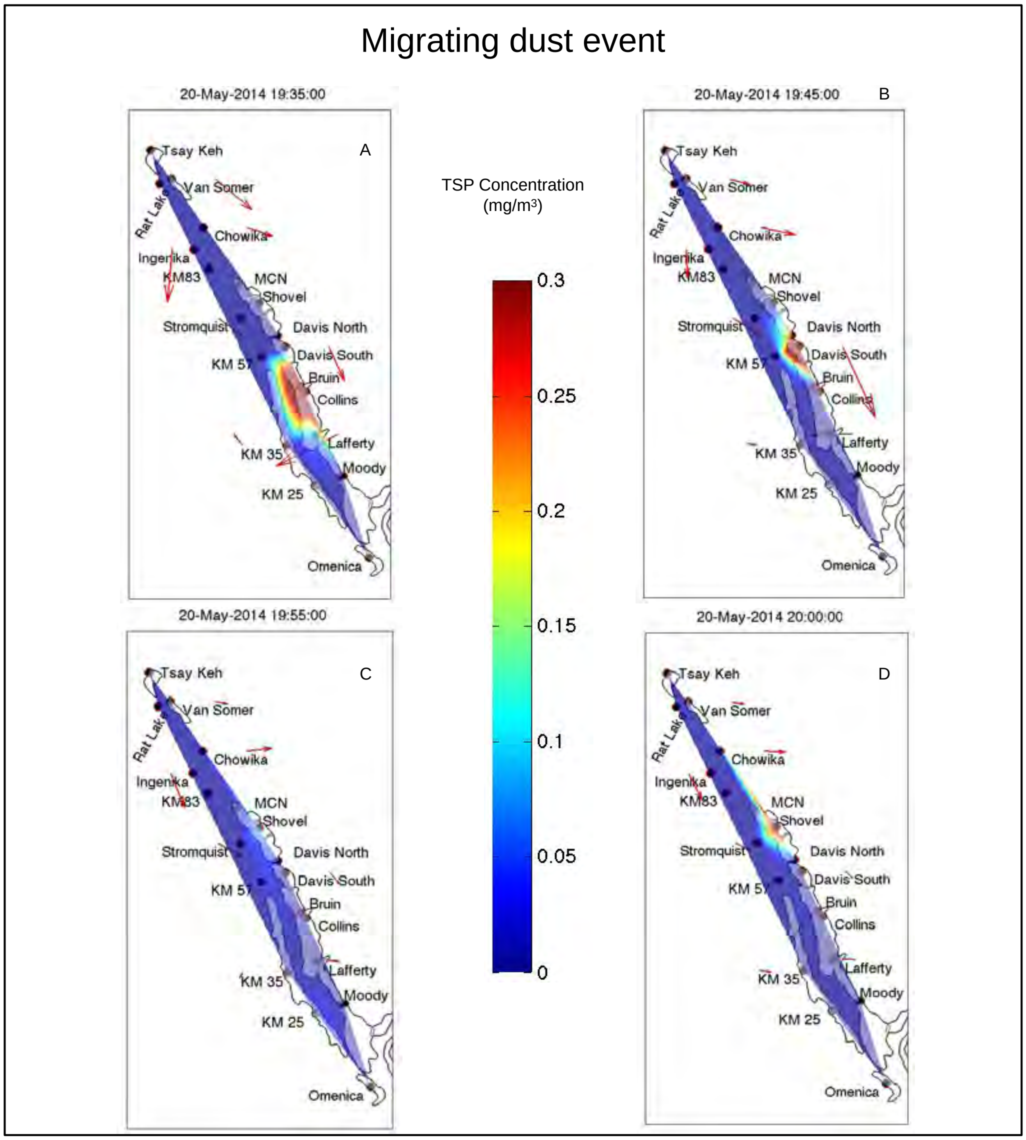


**Figure 22: Heatmap Analysis - Migrating Dust Event – Each plots shows an instantaneous snapshot of the 5-minute average data.**

## Migrating Event:

Figure 22 contains four images, which show the development of a small but migrating dust event. This is perhaps the most interesting new observation that our distributed network of E-Samplers has allowed us to observe. Figure 22 (A) shows the start of a dust event at 19:35 on May 20$^{th}$, 2014 on Collins Beach and Bruin Beach with winds from the south. Figure 22 (B) show the same event 10 minutes later arriving at Davis South and Davis North beaches. Figure 22 (C) shows this same event beginning to arrive at Shovel Creek at 19:55 and then 5 minutes later, Figure 22 (D) shows the event arriving at MCN. There are numerous short-lived events that begin in the southern regions of the Finlay Valley and migrate north like the example in Figure 22. We should note that on May 20th, 2014 this phenomenon had been happening all day, the example shown in Figure 22 was the 3rd such occurrence of the day.

The data collected in 2014 are representative of three typical dust event types that occur in the Finlay Valley. Data collected during the 2015 dust season are representative of a season with very low wind and dust conditions. There were no large-scale dust events that lasted longer than 12 hours and there were no migrating events. Nearly all recorded dust events were related to microburst or convective wind activity. The following figures are used to provide insight into the observations presented above regarding the 2015 dust season. We will provide analysis of a short duration event that occurred in the vicinity of Middle Creek North, a typical 2015 dust event, and the largest event that occurred during the 2015 dust season.

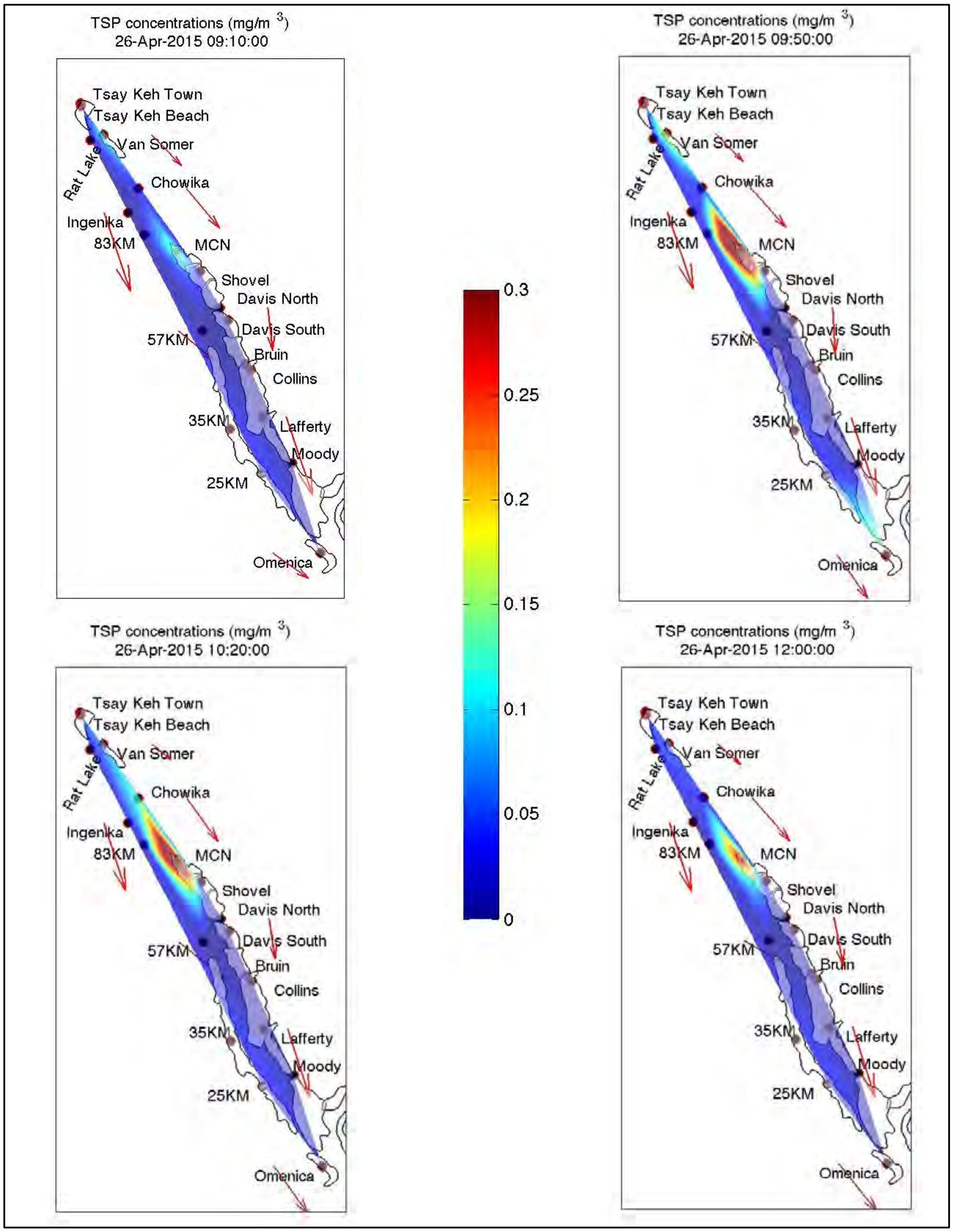


**Figure 23: Short Duration Event at Middle Creek North – Each plots shows an instantaneous snapshot of the 5-minute average data.**

## Short Duration Event:

Figure 23 shows a short duration dust event that occurred at Middle Creek North on April 29$^{th}$, 2015. This event began at 09:00, reached its peak between 10:00 and 11:00 and then quickly subsided shortly after 12:00. This sequence of events occurred on numerous occasions at Middle Creek North in 2015.

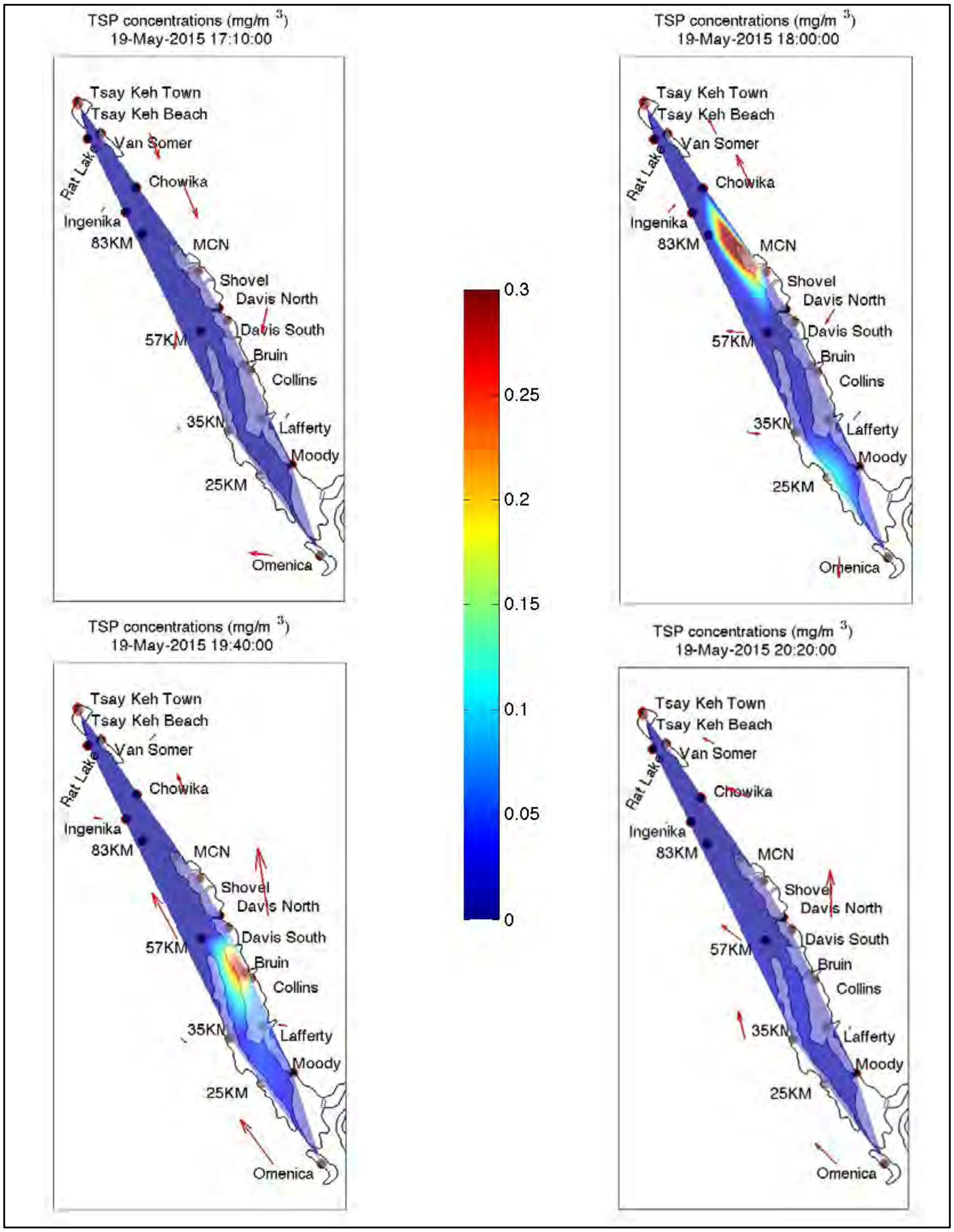


**Figure 24: Dust Event Typical of the 2015 Season – Each plots shows an instantaneous snapshot of the 5-minute average data.**

## Typical Dust Event From 2015:

Figure 24 demonstrates a typical dust event that was observed at multiple instances during the 2015 dust season. AT 17:10 on May 29th, 2015 there was no recorded airborne dust in the valley. Shortly after this at 18:00 dust samplers at Middle Creek North, Shovel, 83km, 35km, and 25km are registering airborne particulate. Notice that the wind vectors are incoherently pointed around the image, indicating that there is no predominant driving wind at this time. By 19:40 the wind has developed and is primarily out of the north. The dust that was present at MCN and 25km has dispersed but there is dust at Bruin. Shortly after this at 20:20 the winds have subsided and the valley is clear of dust again. The failure of these micro-events to evolve into full dust storms was typical of the 2015 season.

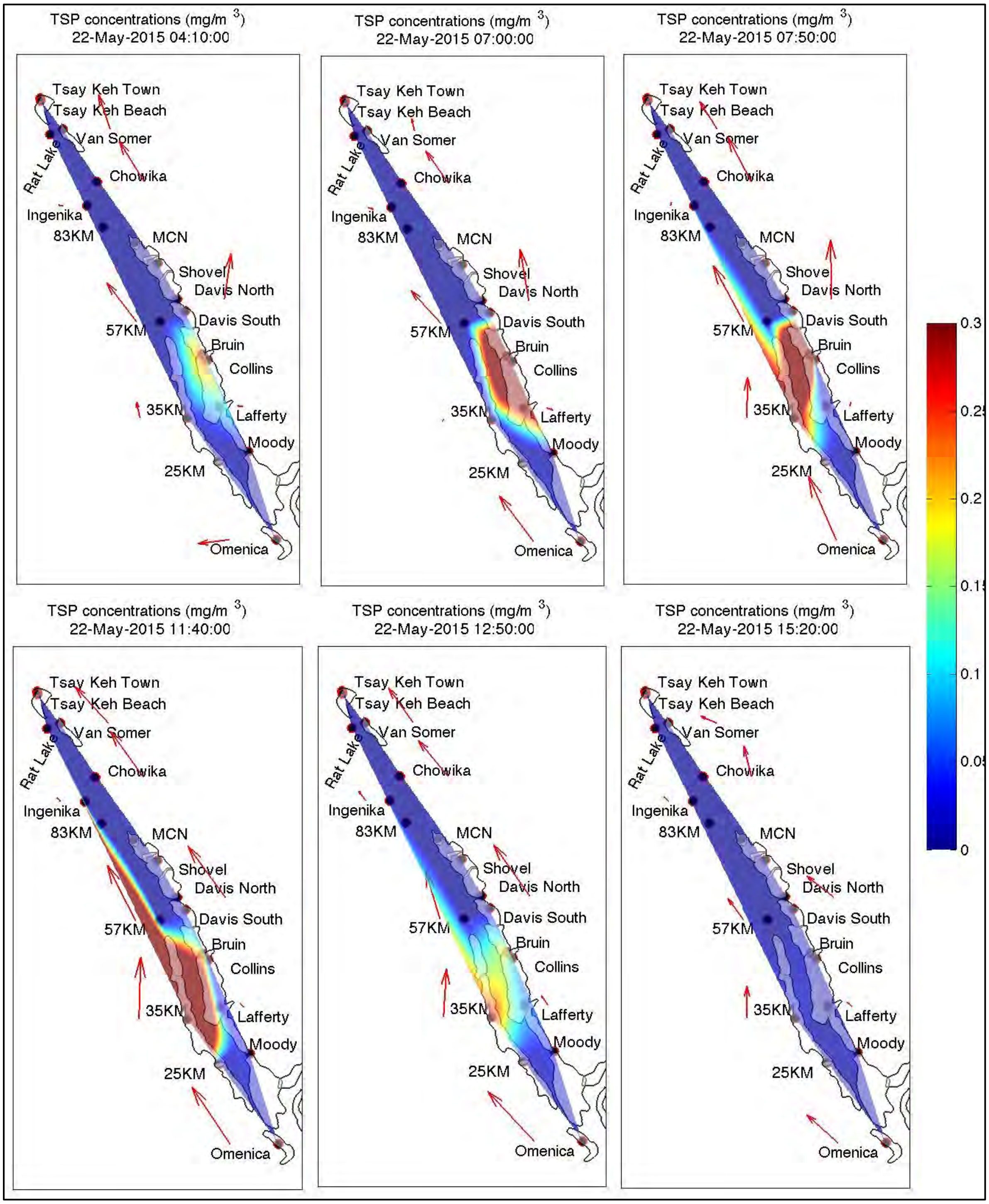


**Figure 25: Largest Dust Event of 2015 – Each plots shows an instantaneous snapshot of the 5-minute average data.**

Figure 25 comprises the sequence of images that demonstrates the largest dust event of 2015. The winds were northerly during this event, which lasted approximately 12 hours. It should be noted that this event stayed relatively localized to the mid-section of the Finlay Arm and did not develop to the extent of the storm that was presented in Figure 20 from 2014.

### 2.2.5 Time-Lapse Analysis

4 Moultrie D-555i game cameras were deployed at selected regional monitoring sites. These cameras were set to record images at 5-minute intervals synced with the collection schedule of the nearby E-Sampler. Although the manufacturer specifications indicated that the Moultrie game cameras would be well suited to this application, in practice the cameras lacked the ability to auto-focus quickly and performed poorly in low light conditions. The cameras were also very inconsistent in power consumption patterns, some batteries lasting months while others would last only 2 weeks. Moving forward we will acquire cameras that represent the latest in affordable time lapse image capture technology for this project.

The primary use of the game cameras was to capture time-data synced images in order to provide a visual record of dust events along side the numerical value for the same event. In this way, the viewer of the video can associate the visual aspect of the dust events to the numerical data read by the E-Samplers.

Videos from the 2014 dust season are posted here:

https://vimeo.com/118043075

https://vimeo.com/117007358

Videos from the 2015 dust season are posted here:

https://vimeo.com/152634706

https://vimeo.com/152631808

When viewing these videos it may be useful to pause for certain frames in order to step through the frames one by one to observe the progression of the dust events.

We will continue analyzing the data in this way, using strong visuals and time lapse to provide greater insight into the dust events. Moving forward we will investigate new and advance analysis techniques that will enable us to extract more detailed information from each video.

## 2.3 Statistical Analysis and Mitigation Treatment Analysis

For this report Chu Cho Environmental will continue with a basic statistical approach to analyzing the Regional Monitoring Network E-Sampler data. As our project team gains experience working with the E-Samplers and comes to know the full capabilities of the instrument and the network design, we will expand upon this analysis to further address the key management question central to this project.

### 2.3.1 Descriptive Statistics and Analysis of Variance

All descriptive statistics and ANOVA operations were performed on data that meet the threshold criteria outlined above. It is not relevant to this discussion to analyze the non-threshold data. Therefore each data point used in the following analyses is above 0.1 $mg/m^3$ TSP and represents a portion of a dust event.

For our analysis of variance we have selected a confidence interval of 99%, which means that our alpha value against which to test our p-value is 0.01.

##### 2.3.1.1 Descriptive Statistics

The following table provides basic descriptive statistics for each of the 18 E-Samplers included in the Regional Monitoring Network.

**Table 7: Basic Descriptive Statistics for the 18 Regional E-Sampler Monitoring Sites (All Units are mg/m³ and were calculated using the 5-minute average data recorded by the E-Sampler)**

| | MCN | Chowika | Shovel | 25Km | Bruin | Tsay Keh Beach | Moody |
|---|---|---|---|---|---|---|---|
| **Mean** | 0.2546 | ~~0.5538~~ | 0.1716 | 0.1635 | 0.276 | 0.2634 | 0.3847 |
| **Minimum** | 0.1 | ~~0.117~~ | 0.1 | 0.101 | 0.102 | 0.103 | 0.123 |
| **Maximum** | 0.966 | ~~0.662~~ | 0.408 | 0.257 | 0.972 | 0.576 | 0.647 |
| **Standard Deviation** | 0.1597 | ~~0.1508~~ | 0.0729 | 0.0483 | 0.1904 | 0.0567 | 0.2744 |
| **Variance** | 0.0255 | ~~0.0227~~ | 0.0053 | 0.0023 | 0.0363 | 0.0032 | 0.0753 |
| | **83Km** | **Davis North** | **Rat Lake** | **Omineca** | **Davis South** | **Van Somer** | **Collins** |
| **Mean** | 0.2095 | 0.2215 | 0.3536 | 0.5159 | 0.1294 | 0.1548 | 0.2564 |
| **Minimum** | 0.1 | 0.1 | 0.116 | 0.1 | 0.1 | 0.1 | 0.119 |
| **Maximum** | 0.604 | 0.426 | 0.884 | 3.885 | 0.181 | 0.459 | 0.7 |
| **Standard Deviation** | 0.1196 | 0.0972 | 0.249 | 0.6782 | 0.024 | 0.0781 | 0.2507 |
| **Variance** | 0.0143 | 0.0094 | 0.062 | 0.4599 | 0.0006 | 0.0061 | 0.0628 |
| | **Tsay Keh Town** | **57Km** | **Ingenika** | **35Km** | | | |
| **Mean** | 0.1383 | 0.2332 | 0.1225 | 0.3868 | | | |
| **Minimum** | 0.1 | 0.11 | 0.107 | 0.1 | | | |
| **Maximum** | 0.491 | 0.856 | 0.138 | 1.579 | | | |
| **Standard Deviation** | 0.0657 | 0.1674 | 0.0219 | 0.3812 | | | |
| **Variance** | 0.0043 | 0.028 | 0.0005 | 0.1453 | | | |

Generally most sites have mean values of similar magnitude (0.1 – 0.25 mg/m$^3$) with a few notable outliers. There most notable outlier sites with values ranging from 0.3 to 0.6 mg/m$^3$ include: Moody, Rat Lake, Omineca and 35km. Note that as mentioned above the data collected at Chowika is suspect and has not been included in the statistical evaluations presented below.

The highest recorded value in 2015 was 3.885 mg/m$^3$ at Omineca, followed by 1.579 mg/m$^3$ at 35km. In 2014 the highest recorded value at Omineca was 2.453 mg/m$^3$ while at 35km the highest recorded value was 5.98 mg/m$^3$. With the exception of Omineca, all other monitoring stations recorded maximum values in 2015 that were several times smaller than the maximum values recorded in 2014.

Moving forward it will be very important to evaluate these data within the context of the many confounding variables that may affect the result. These variables include: Precipitation, Relative humidity, Wind

Speed/Direction and the daily reservoir level. Although we have begun the process of initiating this analysis/modeling exercise, these evaluations are not report ready and have not been included here.

#### 2.3.1.2 ANOVA Between All E-Samplers

We utilize a one-way ANOVA to examine the entire 18-instrument E-Sampler dataset for significant differences in dust concentration data between site locations. This approach will allow us to examine the dataset to determine if there are sites around the reservoir that exhibit significantly higher dust concentrations than others. The null hypothesis for this ANOVA is:

> **$H_0$:** There is no significant difference in the mean dust concentration between all 18 E-Sampler instrument locations.

**Table 8: ANOVA Summary Table for All E-Sampler Data**

| Source | Sun Squares | Degrees Freedom | Mean Squares | F | p-value |
|---|---|---|---|---|---|
| Groups | 17.584 | 18 | 0.97686 | 13.13 | $4.29084e^{-36}$ |
| Error | 87.418 | 1175 | 0.0744 | | |
| Total | 105.002 | 1193 | | | |

Since $p = 4.29084e^{-36} < 0.01$ we may reject the null hypothesis at a 99% confidence interval. Therefore the mean dust concentration between the E-Sampler monitoring sites is significantly different.

The following table provides a Site Name/Boxplot Key to reference the groups shown in Figure 26. Note: There is no E-Sampler located at Lafferty even though it is present in the chart in Figure 26. The data in the Lafferty column are NaN (Not-a-Number) values and have no impact on the overall analysis. We have maintained the data structure in this way incase in the future a dust monitoring site is at Lafferty is added back into the monitoring network.

**Table 9: Boxplot Site Key**

| Site Name | Boxplot Key | Site Name | Boxplot Key | Site Name | Boxplot Key | Site Name | Boxplot Key |
|---|---|---|---|---|---|---|---|
| Middle Creek North | 1 | Moody | 6 | Omineca | 11 | Ingenika | 16 |
| Shovel | 2 | 83Km | 7 | Davis South | 12 | Lafferty | 17 |
| Chowika | 3 | Davis North | 8 | Van Somer | 13 | Collins | 18 |
| 25Km | 4 | Tsay Keh Beach | 9 | Tsay Keh Town | 14 | Bruin | 19 |
| 35Km | 5 | Rat Lake | 10 | 57Km | 15 | | |

Figure 26 is a box and whisker plot showing the results of the ANOVA. The group key in Table 9 can be used to decode which group corresponds to which monitoring stations. Groups 1, 5, 11, and 19, which correspond to Middle Creek North, 35Km, Omineca and Bruin contain a number of outliers within their respective datasets. These four sites are driving the significance within this analysis. The red "+" symbol indicates that the data point is an outlier. There are however a number of sites that contain high outlier values.

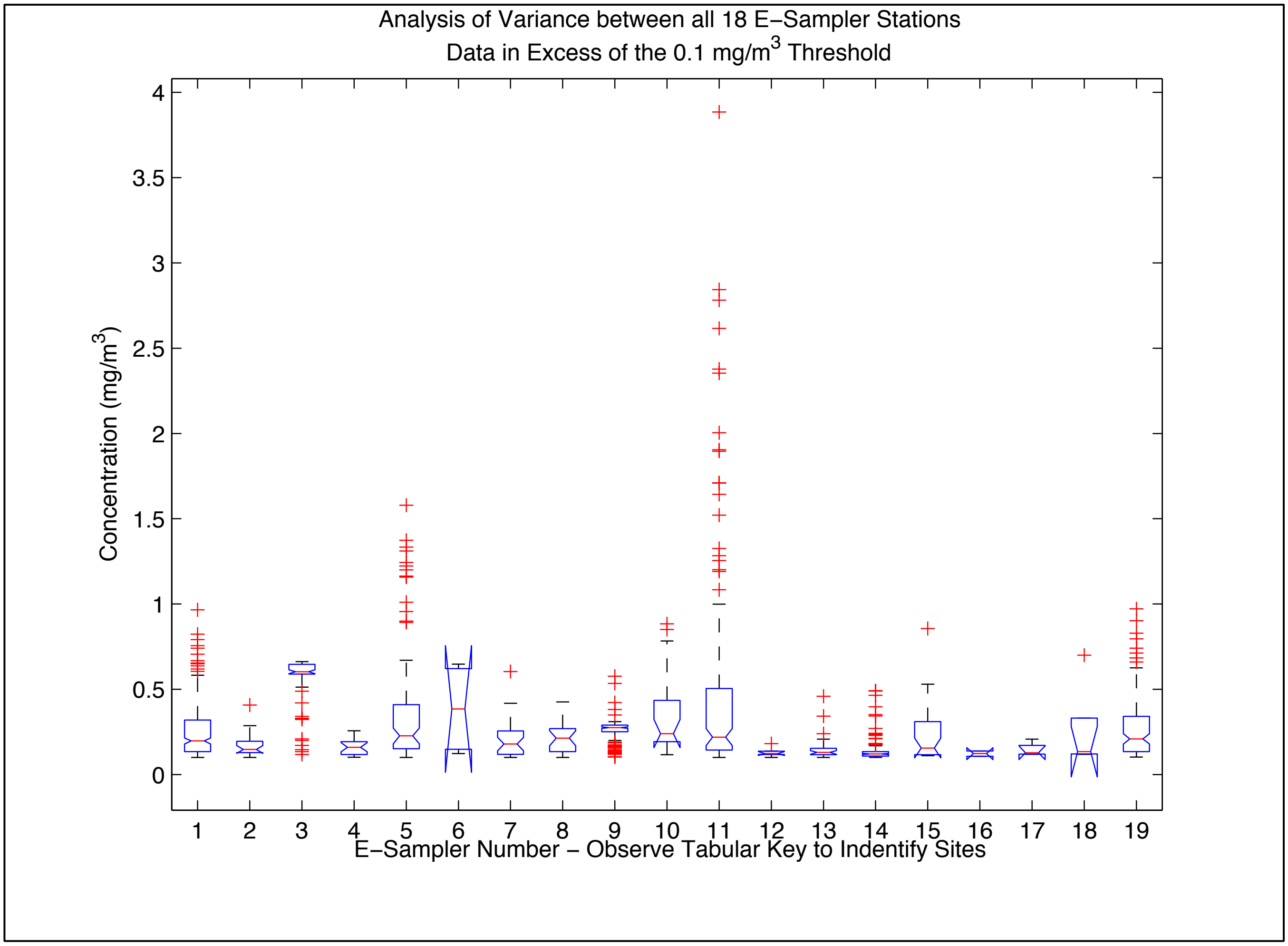


**Figure 26: Results of ANOVA for Entire 18 E-Sampler Dataset**

#### 2.3.1.3 ANOVA Between E-Samplers Located in Non-Erosive Areas

Since significant differences in mean dust event concentrations were identified above, it is relevant to parse the data into two groups, which broadly represent the different geophysical characteristics of the sites. Some sites are located in highly erosive areas while others are located on non-erosive gravel bars and outcrops. We have divided the data into these two groups for the following ANOVA. The first group is the Non-Erosive group and the null hypothesis stated for the ANOVA is as follows:

**$H_0$:** There is no significant difference in the mean dust concentration between E-Samplers that are located in non-erosive zones surrounding the reservoir.

**Table 10: ANOVA Summary Table for E-Sampler Data from Non-Erosive Locations**

| Source | Sun Squares | Degrees Freedom | Mean Squares | F | Prob > F |
|---|---|---|---|---|---|
| Groups | 1.12458 | 5 | 0.22492 | 16.8 | $6.1782e^{-14}$ |
| Error | 2.78439 | 208 | 0.01339 | | |
| Total | 3.90897 | 213 | | | |

Since $p = 6.1782e^{-14} < 0.01$ we may reject the null hypothesis at a 99% confidence interval. Therefore the mean dust concentration values between the E-Samplers located at non-erosive sites are significantly different. Note that Chowika was not included in this analysis because as mentioned above, the datalogger in this E-Sampler was recording non-sense values due to a faulty solar controller. Figure 27 below, is a box and whisker plot of the ANOVA analysis performed on these data. There were a number of outliers associated with Group 4 – Tsay Keh Town and relatively few outliers at the other non-erosional sites. The significance in this test case is primarily driven by Group 1 – Moody, which through multiple comparison was identified as having a mean concentration significantly higher than Group 2 and 4, 83Km and Tsay Keh town, respectively. Group 3 – Rat Lake was also identified a driver of significance in this test case with an average TSP concentration that was significantly higher than Group 2 and 4 as well. Group 1 and Group 3 were not significantly different. Groups 5 and 6 were not significantly different than any of the other groups. Table 11 provides a key for determining which site corresponds to which group in the non-erosive analysis.

**Table 11: Boxplot Name Key for Non-Erosive Sites**

| Site Name | Boxplot Key | Site Name | Boxplot Key | Site Name | Boxplot Key |
|---|---|---|---|---|---|
| Moody | 1 | Tsay Keh Town | 4 | | |
| 83Km | 2 | Ingenika | 5 | | |
| Rat Lake | 3 | Collins | 6 | | |

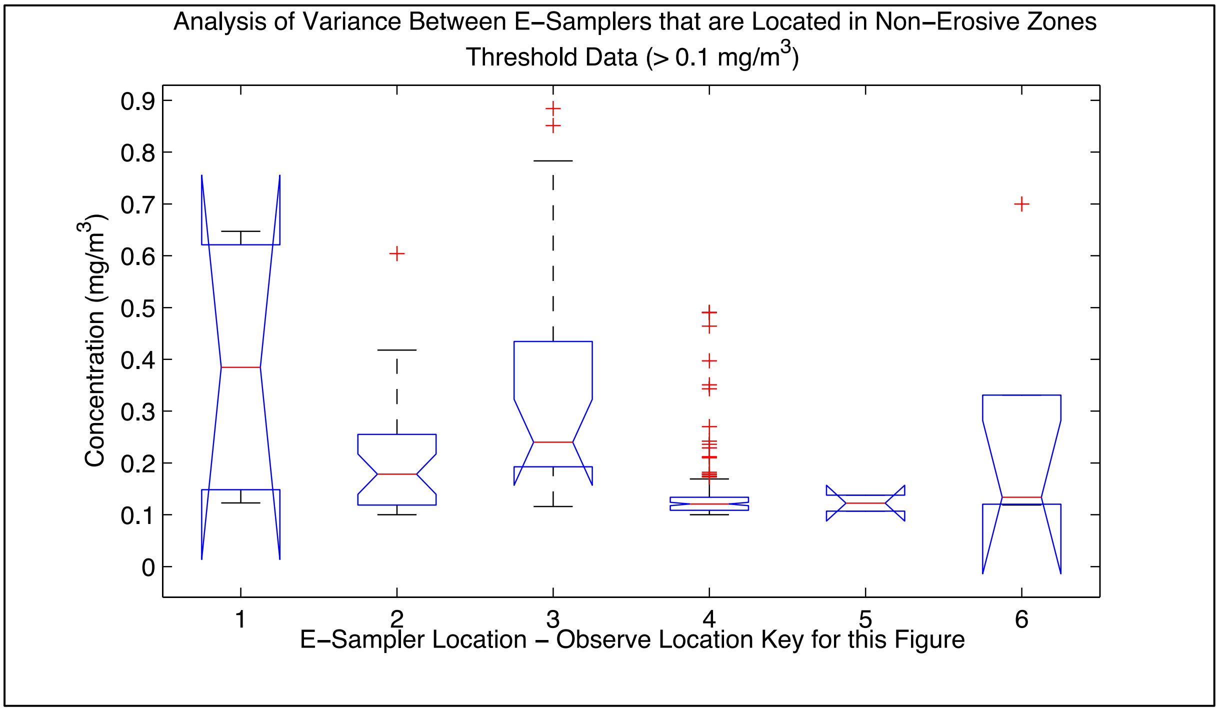


**Figure 27: ANOVA Box and Whisker Plot for E-Sampler Data from Non-Erosional Sites**

#### 2.3.1.4 ANOVA Between E-Samplers Located in Erosive Areas

The second grouping of data represents the E-Samplers that are located in the moderate to highly erosive zones surrounding the reservoir. The null hypothesis for ANOVA of the erosive group of E-Samplers is as follows:

> **$H_0$:** There is no significant difference in the mean dust concentration between E-Samplers that are located in the moderate to highly erosive zones surrounding the reservoir.

**Table 12: Summary Values for the ANOVA of E-Sampler Data Collected in Moderate to highly Erodible Zones**

| Source | Sun Squares | Degrees Freedom | Mean Squares | F | Prob > F |
|---|---|---|---|---|---|
| Groups | 9.3199 | 10 | 0.93199 | 10.12 | $2.94415e^{-16}$ |
| Error | 83.2642 | 904 | 0.09211 | | |
| Total | 92.5842 | 914 | | | |

Since $p = 2.94415e^{-16} < 0.01$ we may reject the null hypothesis at a 99% confidence interval. There are significant differences in dust concentration values between E-Samplers located in moderate to highly erodible zones.

Figure 28 shows that Groups 1, 4, 7 and 11, which corresponds to Middle Creek North, 35Km, Omineca and Bruin Beach contain a number of outliers. Further probing using a multiple comparison reveals that the dust concentration at Group 7 – Omineca is significantly greater than all other locations in the network followed closely by Group 4 - 35km. The significance in this test case is primarily driven by these two locations indicating that these were the dustiest locations during the 2015 dust season. Table 13 provides a key for determining which site corresponds to which group in the erosive analysis.

**Table 13: Boxplot Reference Key for Figure 25**

| Site Name | Boxplot Key | Site Name | Boxplot Key | Site Name | Boxplot Key |
|---|---|---|---|---|---|
| Middle Creek North | 1 | Tsay Keh Beach | 6 | Bruin | 11 |
| Shovel | 2 | Omineca | 7 | | |
| 25Km | 3 | Davis South | 8 | | |
| 35Km | 4 | Van Somer | 9 | | |
| Davis North | 5 | 57Km | 10 | | |

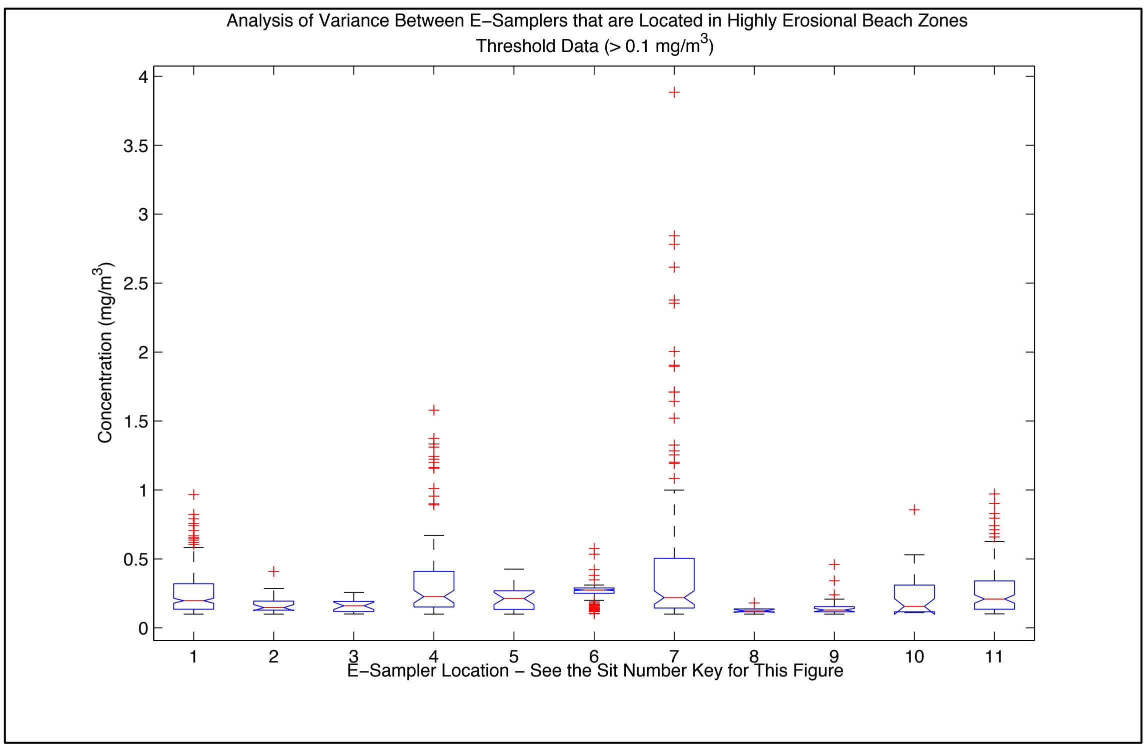


**Figure 28: ANOVA Box and Whisker Plot for E-Sampler Data from Moderate to Highly Erosional Beach Sites.**

### 2.3.2 Mitigation Treatment Analysis

In this section we will analyze the dust concentration recorded at E-Samplers from locations where the tillage date is known for highly erodible beaches. More precisely, we will examine the basic statistics recorded before and after the implementation of the tillage and provide a T-Test comparison of means between these datasets.

Technicians working for the WDMP recorded the day on which tillage was applied to the reservoir beach. For this analysis we will look at dust data for the 14 days preceding tillage and compare them to the 14 days following tillage. The day on which tillage is being applied to the beach is not included in the analysis.

The primary driver for this analysis is to determine if it is possible to tease out a result that might indicate whether or not tillage is effective as a mitigation solution for a given beach. We fully realize that in its current state that this analysis does not adequately address the impact of the various confounding variables such as precipitation, relative humidity and wind direction on the data. Our analytical programming for isolating these effects and improving the efficacy of the evaluative model is improving but at the time of writing this report is not ready.

The data are presented below in Table 14 (2014 data) and Table 15 (2015 data). 2014 was the first year that Chu Cho Environmental began analyzing the frequency and magnitude of threshold dust event data both before and after the application of tillage to reservoir beaches. A subset of data from four highly emissive beaches was selected for this analysis.

**Table 14: 2014 Summary of Beach Tilling Dates and the Before/After Data Collected by the Sampling Equipment – Note: we do not currently posses the before/after reservoir level data. These data are also required to calculate the change in beach area.**

| Beach | Tillage Date | Before /After | Reservoir Level (m a.s.l.) | Avg. Wind Speed (m/s) | Total Precip. (mm) | Av. Rel. Hum. (%) | Avg. Conc (mg/m³) | T-Test P-Value | Change in Beach Area |
|---|---|---|---|---|---|---|---|---|---|
| **MCN** | 2014-06-03 | BF | | 2.91 | 0.6 | 56.54 | 0.010 | 6.24e-7 | |
| | | AF | | 2.73 | 12 | 62.94 | 0.005 | | |
| **Shovel** | 2014-06-02 | BF | | 2.85 | 0.6 | 57.13 | 0.005 | 0.002 | |
| | | AF | | 3.30 | 13.4 | 65.37 | 0.003 | | |
| **35Km** | 2014-06-02 | BF | | 2.20 | 1.1 | 61.52 | 0.024 | $1.10e^{-12}$ | |
| | | AF | | 2.73 | 3.5 | 63.50 | 0.083 | | |
| **Van Somer** | 2014-05-19 | BF | | 2.25 | 7.1 | 62.11 | 0.005 | $4.55e^{-6}$ | |
| | | AF | | 2.24 | 3.5 | 60.52 | 0.008 | | |

In general, the 2014 data suggest there is limited evidence supporting that the application of tillage to a given beach will result in a direct reduction of fugitive dust emissions from a given beach. The four test cases used in this analysis present significant but confounding results. In 2 cases the emissions decreased significantly but there was less than 1mm of rain prior to tillage and over 10mm of rain after tillage. Rainfall is often associated with wind events and as such it was impossible to completely isolate tillage effects from rainfall effects. The two remaining cases showed significant increases in fugitive dust emissions following the application of tillage, however for both of these locations there was more rain prior to tillage and less rain following tillage. These results are somewhat confounding but generally support the thesis that tillage does not significantly reduce fugitive dust emissions from reservoir beaches.

Note that the Reservoir Level column has been left blank only because our project team has not been able to obtain accurate legacy reservoir elevation data.

In general, variables like rainfall amount and reservoir recharge rate appear have a stronger influence on the fugitive dust emissions from a given beach than does applying tractor tillage.

The data presented in Table 14 are both interesting and somewhat confounding. A T-test comparison of means was performed on the dust concentration data parsed out from before to after the application of tillage on a given beach. In all cases our T-test was designed to test the following null hypothesis at a 99% confidence level (alpha = 0.01):

> **$H_0$:** There is no significant difference in the mean dust concentration values from data collected 14 days before the application of tillage on a given beach to those collected the 14 days following the application of tillage.

In all cases the p-value was less than the alpha test values, therefore we can reject the null hypotheses and accept that there is a significant difference in the data from before and after the application of tillage on the given test beaches. However, the direction of the significance is not the same in all cases, two sites showed a decrease in dust readings while the remaining two showed an increase. Ultimately this means that our control and test variables are not well constrained. There are a host of other factors that are affecting these results.

At MCN and Shovel there was a significant decrease in fugitive dust emissions after the application of the tillage. However, at MCN in the 14 days leading up to the application of the tillage there was only 0.6 mm of rain while in the 14 days following the tillage there was 12 mm and at Shovel there was 0.6 mm before tillage and 13.4 after. The before/after wind speed and relative humidity are not strongly different in these cases. Ultimately, this means that we cannot completely attribute the decrease in dust emissions to the effect of the tillage, since there was so much rain in the days following the application of the tillage. More data is needed to constrain these results.

At 35Km there was a significant increase in fugitive dust emissions following the application of the tillage. The average wind speed was slightly higher and could explain some of the increased emissions recorded at the E-Sampler, but not completely. The total rainfall and average relative humidity were both higher as well but clearly not enough to slow down the dust emissions. Even though 35Km was tilled on the same day as MCN we know that weather around the reservoir can be highly localized and this is likely why we are seeing such high rainfall volumes at MCN and Shovel and minimal values at 35Km. In this case there is no reason to believe that tillage is effective here, in fact the data demonstrate the opposite, but as we said before, more data and analysis is required to constrain these results.

At Van Somer there was a significant increase in average fugitive dust emissions following the application of tillage. There was very little change in the average wind speed and a decrease in both rainfall amount and relative humidity. It would appear that as this site "dries out" following the application of tillage that the fugitive emissions begin to increase for the same given wind speed. Tillage begins to breakdown immediately following its application although some beach sediment types tend to hold it longer. Van Somer was part of a 2013 study and was shown to have very good prospects as a beach that would accept and maintain useful tillage for 10 – 14 days (Tilson et al. 2013). However, this is one beach and one sampler looking at a small subset of the data and as we've said above, more data is needed to constrain the results.

**Table 15: 2015 Summary of Beach Tilling Dates and the Before/After Data Collected by the Sampling Equipment – Note: we do not currently posses the before/after reservoir level data. These data are also required to calculate the change in beach area.**

| Beach | Tillage Date | Before /After | Reservoir Level (m a.s.l.) | Avg. Wind Speed (m/s) | Total Precip. (mm) | Av. Rel. Hum. (%) | Avg. Conc (mg/m³) | T-Test P-Value | Change in Beach Area |
|---|---|---|---|---|---|---|---|---|---|
| **MCN** | Not tilled | | | | | | | | |
| | | | | | | | | | |
| **Shovel** | 2015-05-10 to 2015-05-20 | BF | | 2.55 | 3.2 | 56.88 | 0.005 | 0.14 | |
| | | AF | | 2.97 | 17.6 | 65.22 | 0.004 | | |
| **Omineca** | 2015-05-11 to 2015-05-20 | BF | | 2.75 | 2.7 | 56.16 | 0.01 | 0.14 | |
| | | AF | | 2.74 | 50.8 | 64.175 | 0.013 | | |
| **Van Somer** | 2015-05-06 to 2015-05-09 | BF | | 2.19 | 6.4 | 63.29 | 0.006 | 0.84 | |
| | | AF | | 1.83 | 1.1 | 47.75 | 0.006 | | |
| **Bruin** | 2015-05-21 to 2015-05-23 | BF | | 2.42 | 0.00 | 50.01 | 0.02 | 0.1 | |
| | | AF | | 2.94 | 23.2 | 73.22 | 0.017 | | |

The 2015 data yielded similar results to 2014, but since 35km Beach and Middle Creek North beach were not tilled in 2015 we elected to include samplers from Omineca and Bruin Beach in the 2015 analysis. Bruin Beach is highly influenced by emissions from Collins North Beach and Lafferty.

There was no difference in wind direction before and after the application of tillage at any station. At Shovel, Omineca and Bruin there was a sharp increase in rainfall in the two weeks following the application of tillage and there was a slight increase in the average wind speed at these beaches. At Van Somer there was slightly more rain before the application of tillage and a slight decrease in wind speed after tillage.

At Shovel, Omineca and Van Somer, there was no significant change in fugitive dust emissions in the data collected 2 weeks prior to tillage when compared to the data collected 2 weeks after tillage.

There was a significant decrease in fugitive dust emissions at Bruin Beach but since the total rainfall increased from 0mm before tillage to 23.2mm after tillage and the relative humidity increased from 50.01% to 73.22% it is not possible to attribute the significant decrease to tillage effects alone.

Furthermore, it should be noted that no T-test on the 2015 data yielded significant results, that is we cannot reject the null hypothesis presented above and cannot conclude that there is a difference in the before/after tillage dust concentration values.

There was not sufficient enough wind in 2015 to generate dust events from which our project team could extract meaningful data. 2015 was a year like no other observed since 2008.

Simply looking at averages and drawing multiple and confounding conclusions is not our intention with presenting this avenue for analysis. Chu Cho Environmental has included this piece in the analysis to indicate where we are heading and what our future plans are for the enormous amount of data that is amassed by the regional monitoring network. We will be expanding this work through collaboration with industry modeling experts to create strong analysis approach following this path.

## 2.4 General Discussion Related to the Regional Monitoring Network

Chu Cho Environmental's updated continuous monitoring network has given us the ability to observe the small-scale and migrating events that would otherwise be missed with periodic non-continuous sampling. Examples such as those shown in Figures 20 through 25 in Section 2.2.4 provide powerful examples of the type of analyses we are able to conduct with the data collected by the new Regional Monitoring Network. This will ultimately allow us to observe, on a much more detailed level, the impact that mitigation treatments are having on reservoir dust concentrations.

Although this report represents the start down many new analysis pathways, we would like to remind the reader that the results presented in this report are preliminary and that significant improvements will be made with each new iteration of this report and moving towards our final 10-year dataset analysis in 2018.

## Network Component II: Reference Monitoring Network

# 3.0 Reference Monitoring Network

## 3.1 Network Characterization

Canadian Ambient Air Quality Standard (CAAQS) achievement determination requires that the Reporting Areas (RA) be based on the Census Metropolitan Areas (CMA) and census agglomerations (CA). Therefore, the distribution of CAAQS reporting stations is based on population numbers and urban density (CCME 2011). Generally, for CAAQS reporting there should be 1 particulate sampler for every 250,000 people and the sampler should be placed between 6 – 8 km apart or should have a distribution that is dependent on the distance between the CMA and the major source that may be affecting it (CCME, 2011).

The province of British Columbia uses a suite of ambient air quality criteria that have been developed provincially and nationally to inform the decisions on the management of air contaminants (BC MoE, 2013). The suite of criteria that are applicable to this report include the Provincial Ambient Air Quality Objectives (AQOs), the CAAQS and the Pollution Control Objectives (PCOs) of industry. The most recent revisions to the BC Ambient Air Quality Objectives were accepted in June 2013. Those that are relevant to this project include:

**Table 16: Air Quality Objectives and Standards Relevant to this Project**

| Contaminant | Average Period | Objective/Standard | Date Adopted | Source |
|---|---|---|---|---|
| PM2.5 | 24 Hour | 28 $\mu g/m^3$ | 2013 | CAAQS |
| PM2.5 | Annual | 10 $\mu g/m^3$ | 2013 | CAAQS |
| PM10 | 24 Hour | 50 $\mu g/m^3$ | 2005 | Provincial AQO |
| Dustfall | 1 Month - Lower | 1.7 $mg/(dm^2*day)$ | 1979 | PCOs for Mining, Smelting and Related Industries |
| Dustfall | 1 Month - Upper | 2.9 $mg/(dm^2*day)$ | 1979 | PCOs for Mining, Smelting and Related Industries |

### 3.1.1 GMSMON#18 Air Monitoring Network Characterization

The reference monitoring network managed by Chu Cho Environmental in the Finlay Valley meets or exceeds the above criteria as it consists of two major monitoring stations located approximately 72km apart in villages with less than 400 people. The monitoring station in Tsay Keh Dene is located approximately 450m away from the edge of the major source which affects the village (the reservoir) and is sited away from any structures or other impediments to air flow that might bias the sample. The monitoring station in Kwadacha is located approximately 75km away from the reservoir along the Rocky Mountain Trench and within the village is sited reasonably far away from structures and other impediments to airflow. The spatial distribution of these samplers fits within the Regional Scale category for monitoring and since the populations of both Tsay Keh Dene and Kwadacha are less than 400 each, our Reference Monitoring Network is considered adequate to meet the standards for CAAQS reporting as well as Special Studies (British Columbia Air Protection Section Environmental Quality Branch, 2006).

Figure 27 below, shows the location of each monitoring station within the Finlay Valley relative to the reservoir. The Finlay Valley tends to direct the wind flow either northwest or southeast; all recorded dust events are generated by southeasterly winds. The valley is approximately 10km wide at Tsay Keh Dene and narrows to less than 4km at Kwadacha. Figure 28 shows the Tsay Keh Dene monitoring station outfitted with an E-Sampler, 2 BGI PQ200s, relative humidity/temperature sensor, barometric pressure sensor, rain gauge, and a wind speed/direction monitor. Figure 29 shows the Kwadacha monitoring station outfitted with a relative humidity/temperature sensor, barometric pressure sensor, rain gauge, and a wind speed/direction monitor.

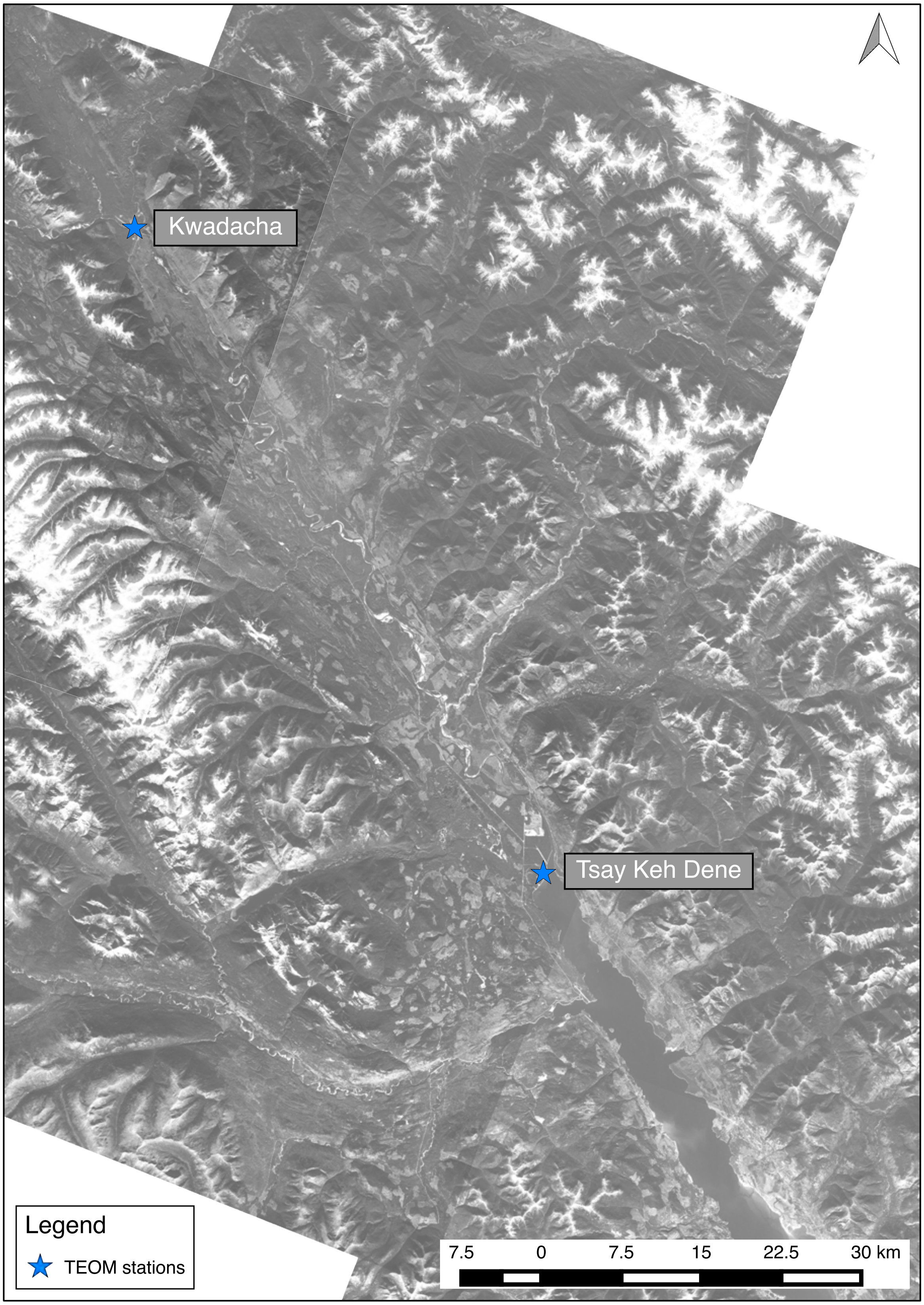


Figure 29: GMSMON#18 Reference Monitoring Network

Figure 30: Tsay Keh Dene Air Monitoring Station

Figure 31: Kwadacha Air Quality Monitoring Station

### 3.1.2 Instrumentation

The GMSMON#18 air quality monitoring project uses both Federal Reference Monitoring (FRM) and Federal Equivalent Monitoring (FEM) equipment for measuring and verifying air quality.

**FEM:**

- Thermo-Fischer Scientific TEOM 1405-D Dichotomous Ambient Particulate Monitor.
- U.S. EPA Designation EQPM-0609-182 for $PM_{2.5}$ (U.S. EPA 2012)
- U.S. EPA Designation EQPM-1090-079 for $PM_{10}$ (U.S. EPA 2012)
- FEM instruments estimate mass concentration by using an active sensor to determine the particle concentration within a flow-controlled air stream where the sample is collected. The sensor responds to the presence of particles in the air stream and is designed to measure the mass concentration of particles in the air stream with a known precision and accuracy.
- The TEOM (Tapered Element Oscillating Microbalance) measures the volume of particulate in the air by calculating the amount by which the oscillation of the microbalance is attenuated as particles land on the filter, which sits atop the microbalance. In order to perform this calculation the TEOM must maintain and record a steady airflow through the instrument.
- Instrument maintenance and calibration techniques are implemented to ensure that the microbalance oscillation and flow volumes through the instrument remain constant and do not drift.
- The TEOM 1405-D reads the oscillation at 1Hz and records the average particulate concentration over 10-minute, 8-Hour, and 24-Hour periods.

The TEOM units were installed in the fall of 2011 and became fully operational in January of 2012, thus 2014 represented the 3rd complete year of operation for the system. The CCME guidelines require three years of valid data in order to evaluate and validate the data against the CAAQS. However, the data collected from December 2012 to April 2014 are not of a known quality and Chu Cho Environmental has not been able to obtain records of maintenance or calibration performed during this time period. Chu Cho Environmental will use the raw high frequency data that is stored on the TEOMs internal memory to verify as best as possible the data from this record but with no maintenance records the data will not be considered valid for use in CAAQS determination. Furthermore, TEOMs themselves are a notoriously unreliable instrument suffering frequent breakdowns that stop the collection of valid data. In 2015, the TEOM in Kwadacha suffered a circuit board failure. This TEOM was removed on July 7th, 2015, sent to the manufacturer for repair and at the time of writing this report (January 2016) has not yet been returned. We suspect that we will receive the instrument in February 2016. The TEOM in Tsay Keh Dene performed well during 2014 and 2015, however Chu Cho Environmental did have to replace the flow controller circuit board in this TEOM but it was done onsite with less than 8 hours down time.

Given the lack of maintenance records, unknown data quality from previous years and large portions of missing data, we are unable to perform a proper CAAQS determination for this report. We will however evaluate the data collected by these instruments within the context of the CAAQS and the Provincial AQOs by simply comparing the results of our analysis to the standards/guidelines provided by the Federal and Provincial governments. To be clear, the data presented in the following sections should not be considered valid for comparison to health standards or otherwise. We will use them here to provide insight into the air quality in Tsay Keh Dene and Kwadacha and to work towards addressing the key management question. Once we obtain proper service records and have created the algorithms required to process the high frequency TEOM data, it is our plan to include a CAAQS determination calculation for $PM_{2.5}$.

For this project, 2 FRM instruments are co-located in Tsay Keh Dene with the FEM sampler and are used for data validation and verification. BGI PQ200s were not deployed in 2015 due to equipment failures but will be deployed in 2016.

**FRM:**

- BGI PQ200 Ambient Particulate sampler.
- U.S. EPA designation RFPS-0498-116 for $PM_{2.5}$ (U.S. EPA 2012)
- U.S. EPA designation RFPS-1298-125 for $PM_{10}$ (U.S. EPA 2012)
- BGI PQ200s are robust and easily configurable for $PM_{2.5}$ or $PM_{10}$ applications.
- BGI PQ200s do not provide continuous PM monitoring and require significant labor costs and analysis costs for collecting air quality data.
- From 2012 – 2013 these were the primary instrument used to address the key management question posed by GMSMON#18 however, Chu Cho Environmental does not believe that these instruments are capable of doing this for two reasons:
  - These instruments can only record 24-hour average data and we know that reservoir dust storms may be short and sporadic in duration.
  - The labor costs in managing the instruments constrain the number of devices that can be deployed around the reservoir.
  - For these reasons the BGI PQ200 units are no longer being used to address the GMSMON#18 key management question.
- The BGI PQ200 units are used as independent verification tools for examining the validity of the TEOM 1405-D data.

- FRM Machines use a standard air filter that becomes loaded with particulate as air is pulled through the instrument. These filters are usually 47mm in diameter and must be placed in a sealed chamber across the flow path. Air is pulled though the instrument at 16.67 lpm for 24 hours. The filters are removed after 24 hours in the machine and are sent to a lab for gravimetric analysis to determine the mass of the particles that were deposited on the filter. Using the mass of particulate on the filter, the flow volume and the time that the filter was in the instrument the particulate concentration is calculated in $\mu g/m^3$.

### 3.1.3 Reference Monitoring Network Data Quality Objectives

When assessing the data obtained from the Reference Monitoring Network for completeness and validity, Chu Cho Environmental utilizes the following DQOs:

- Accuracy:
  - The TEOM 1405-D units must be calibrated and maintained to sustain an accuracy of greater than +/- 10%.
- Precision:
  - The TEOM 1405-D units must be calibrated and maintained to sustain a precision that deviates less than 10% deviation from a zero standard. This is done through $K_0$ Verification, Leak Checking and Flow Auditing.
- Completeness:
  - In order to be considered a valid data reading the TEOM 1405-D must record data for greater than 75% of the available hours within a day. This means that in order to be considered a valid day of data there must be at least 18 hours of data recorded.
  - During the hours of data collection the TEOM 1405-D must be operating within the tolerances described above for accuracy and precision not only with respect to the oscillating microbalance but also for the flow controllers and auxiliary instrumentation.
  - In order to be considered a valid dataset the TEOM 1405-D must record at least 70% of the available hours within a year.
- Comparability:
  - We maintain a small subset of filter based monitoring instruments that are used to collect samples at random times for comparison to TEOM 1405-D data. These data are used to provide assurance that the TEOM 1405-D units are maintaining proper function through time. Note, these instruments were not used in 2015 but will be in 2016.

- Averaging Period:
  - TEOM 1405-D data are measured at 1Hz and are recorded at 10-minute averages to the on-board memory, the CR1000 datalogger and the backup computer system. These data are downloaded and verified once or twice per month.
- Measurement Cycle:
  - TEOM 1405-D data is collected from January until December of each year. Data analysis is focused on the Period from April to June or what is typically called the dust season. For CAAQS determination the analysis is expanded to focus on the entire annual dataset and moving forward will incorporate the data collected since 2011.
- Spatial Representativeness:
  - The samplers are located in areas where they will not be influenced by external factors that may cause sample bias. This includes the following specifications:
    - Sampler intake height is 5 meters above the earth's surface.
    - Sampler is located sufficiently far away from roadways and other sources of external contamination such as incinerators or factories.
    - Sampler intake is located sufficiently far away from airflow restrictions through 360 degrees of rotation and must be located at a distance away from an object that is at least 3 times the height of that object.
    - Sampler intake is located greater than 20 meters away from trees.
- Data Verification:
  - Data verification is the process by which the data are assessed to ensure that the minimum criteria are met for completeness and comparability. This process is automated through computer scripting and is completed 4 times annually.
  - As the data are processed, invalid days or measurements that are suspect are flagged so that the technician performing the verification can then manually inspect the data for the issue. This two-step process is essential in ensuring that the data collected by our network are meeting the requirements of our DQO program.

Chu Cho Environmental ensures that suitable technical procedures are in place to record and catalog the processes that lead to successful achievement of the DQOs.

### 3.1.4 Methodology

In order to ensure that the data collected by the baseline monitoring stations are of a known quality we have implemented a Quality Assurance/Quality Control (QA/QC) program that is built on the guiding principles of the provincial monitoring network (BC MoE, 2009). For this project, Chu Cho Environmental utilizes a strict schedule of sites visits, instrument calibrations and audits and data validation.

TEOM 1405-D air samplers require that the primary air filters be changed every 6 weeks or sooner as the filter loading approaches 90%. During each filter exchange members of our project team also perform the basic calibration and verification procedures to ensure that the TEOM and its meteorological equipment are functioning properly, these procedures include:

- $K_0$ spring constant verification of the oscillating TEOM components,
- Leak check verification to ensure that the TEOM is air tight,
- Inspection of numerical data recorded by the dataloggers to ensure that all instruments are functioning properly and that the readings reflect a reasonable reality,
- A visual inspection of all meteorological and TEOM equipment,
- The TEOM enclosure is swept and all surfaces are cleaned with an ammonia based cleaning agent,
- The data system is inspected to ensure that all data are being recorded to the appropriate location and are being backed-up at regular intervals.

After every third filter exchange or sooner if necessary, members of our project team will perform the more advanced calibration and verification procedures that are required to ensure proper TEOM function, these include:

- The flow rates are audited and calibrated for each airflow channel: Bypass, $PM_{2.5}$, $PM_{Coarse}$
- The virtual impactor is dismantled and thoroughly cleaned using and ammonia based cleaner,
- All rubber gaskets are greased with vacuum seal silicon,
- All voltage points within the TEOM unit are checked to ensure that the numerous sensors are functioning properly,
- The additional TEOM sensors are calibrated, this includes the air pressure and temperature sensors.

In addition to the standard maintenance routines required to ensure data validity, there are several long-cycle routines associated with the physical TEOM components that suffer wear-and-tear. These items include the air pump (18 – 24 months) and several of the onboard sensors, which monitor airflow or temperature for example.

After each visit to the TEOM station our team technicians record their activities in a logbook that is kept inside the TEOM enclosure. Data in this logbook are transcribed into a Word document at regular monthly intervals. This logbook is an important component of the QA/QC procedures.

By carefully crafting and implementing our QA/QC strategy we have managed to achieve a very high standard for data quality with only four data outages related to failing TEOM system components. Regular data outages are recorded when the technicians perform maintenance routines such as filter exchanges or $K_0$ verification but these are unavoidable. In order to be considered a valid data day the TEOM must record data for more than 75% of the available hours in a 24 hour period. Since the TEOM units were re-installed on May 7th, 2015 by Chu Cho Environmental we have had four missed data days at each of the TEOM units.

## 3.2 Reference Monitoring Network Data Overview

For this Year-8 final report we will analyze the 2015 datasets from the period covering January 2015 to December 2015, collected at both Tsay Keh Dene and Kwadacha.

### 3.2.1 Tsay Keh Dene Monitoring Station 24 Hour Average Air Quality and Meteorology Characterization

Figure 32 (a) through (d) shows plots of the 24-hour average meteorology and air quality data recorded at the Tsay Keh Dene monitoring station during between the period from January 2015 to December 2015.

**Meteorology:**

In general, the 2015 dust season was warmer, dryer and much less windy than the 2011, 2012, 2013 (Nickling et al. 2013), and 2014 (Tilson, 2015) seasons. This generally resulted in a decrease in the number of overall dust events. Interestingly, precipitation levels from March to mid-July remained low and at that point increased and remained high through the fall. The combination of warm dry weather during the spring and early exposure of the reservoir beaches would typically give rise to a number of dust events. The potential for dust events was exacerbated by the low relative humidity recorded during May and June that would contribute to increasing the mobility of beach sediments. However, there was minimal wind during the spring of 2015 as persistent high-pressure systems that prevented the formation of the usually strong winds associated with seasonal change at this time of year. During the typical dust season there was no daily average wind speed greater than 4.0 m/s, contrast this with 2013 and 2014, which had several events where the daily average wind speed was in excess of 6.0 m/s. Precipitation and relatively humidity are shown in Figure 32 (d) and air temperature and air pressure are shown in Figure 32 (c). Unfortunately the barometric pressure sensor stopped functioning in May 2015 and was not returned from the manufacturer until September 2015.

Winds are generally oriented along the Finlay Valley and so either come from the Northwest or Southeast. Wind speed and wind direction are shown in Figure 32 (b). The wind barbs shown in Figure 32 (b) are not visible because there is too much information on this graph. For this reason we have also included a wind rose in Figure 33 that shows wind direction and magnitude. Figure 33 demonstrates the persistency of the Northwest/Southeast winds in Tsay Keh Dene and indicates that Southeast is the predominant direction overall.

## 24-Hour Average Dust Concentrations:

24-hour average PM concentrations are shown in Figure 32 (a). The brown line represents $PM_{10}$ and the green line represents $PM_{2.5}$. The colour coded dashed lines across the plot represent the exceedence standards, that is an Air Quality Objective (AQO) of 50 $\mu g/m^3$ for $PM_{10}$ and 28 $\mu g/m^3$ for $PM_{2.5}$ (CCME, 2012).

We see that when averaged over 24 hours there was only a single exceedence of the CAAQS or BC AQOs at the Tsay Keh Dene monitoring station for $PM_{10}$ and zero exceedences for $PM_{2.5}$. The exceedence occurred on May 14th, 2015 with value of $PM_{10}$ = 62.42 $\mu g/m^3$ and $PM_{2.5}$ = 15.14 $\mu g/m^3$. Since there was only a single $PM_{10}$ exceedence in 2015 we have opted not to include this information in a table.

There is a small data gap between May 3rd, 2015 and May 8th, 2015 when there was a power failure in Tsay Keh Dene and the system auto-reboot did not effectively initiate that startup sequence, as verified by the E-Sampler Regional Monitoring Network there were no dust events during this period.

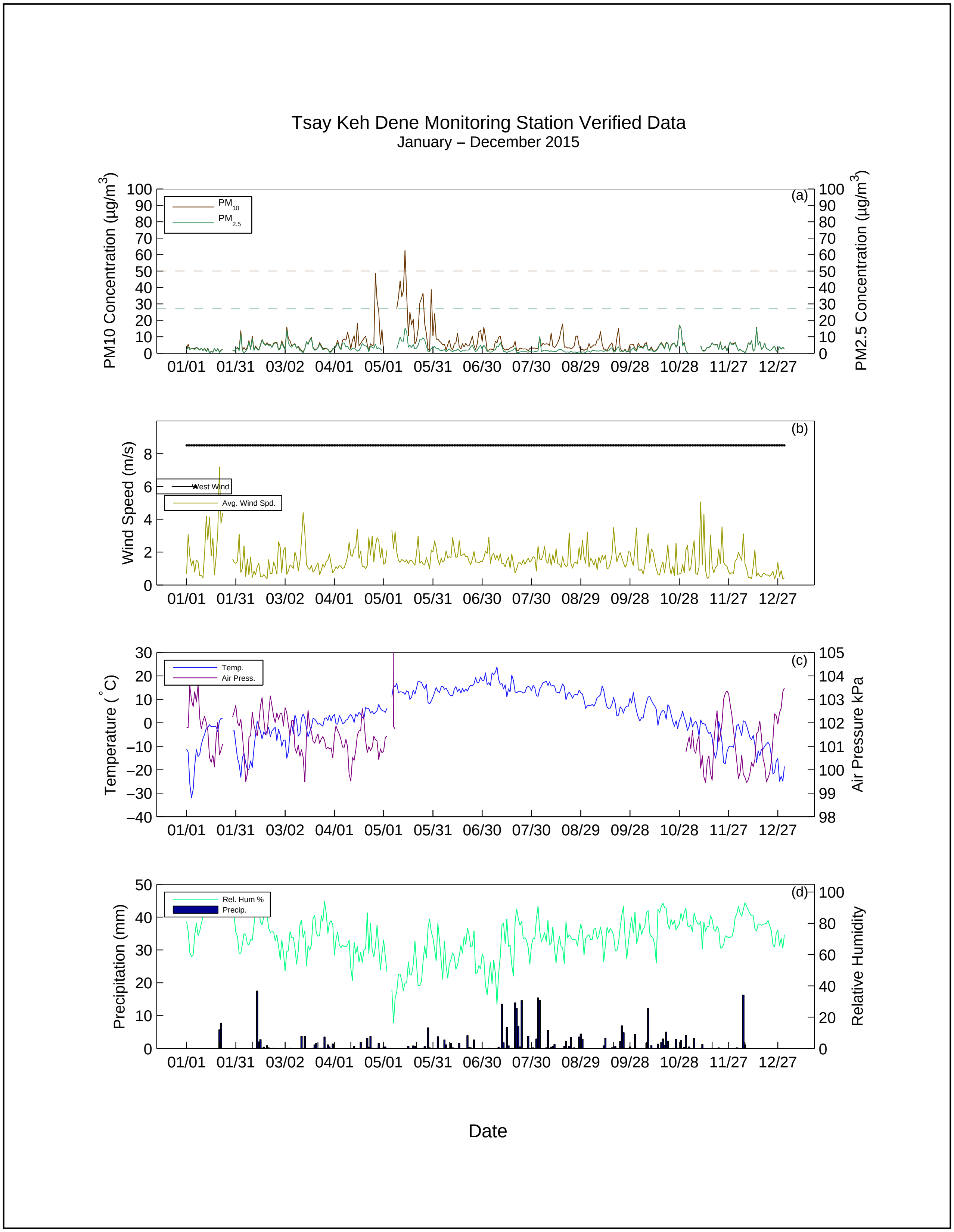


**Figure 32: 2015 Tsay Keh Dene Air Quality Monitoring Station Data – 24 Hour Average Data**

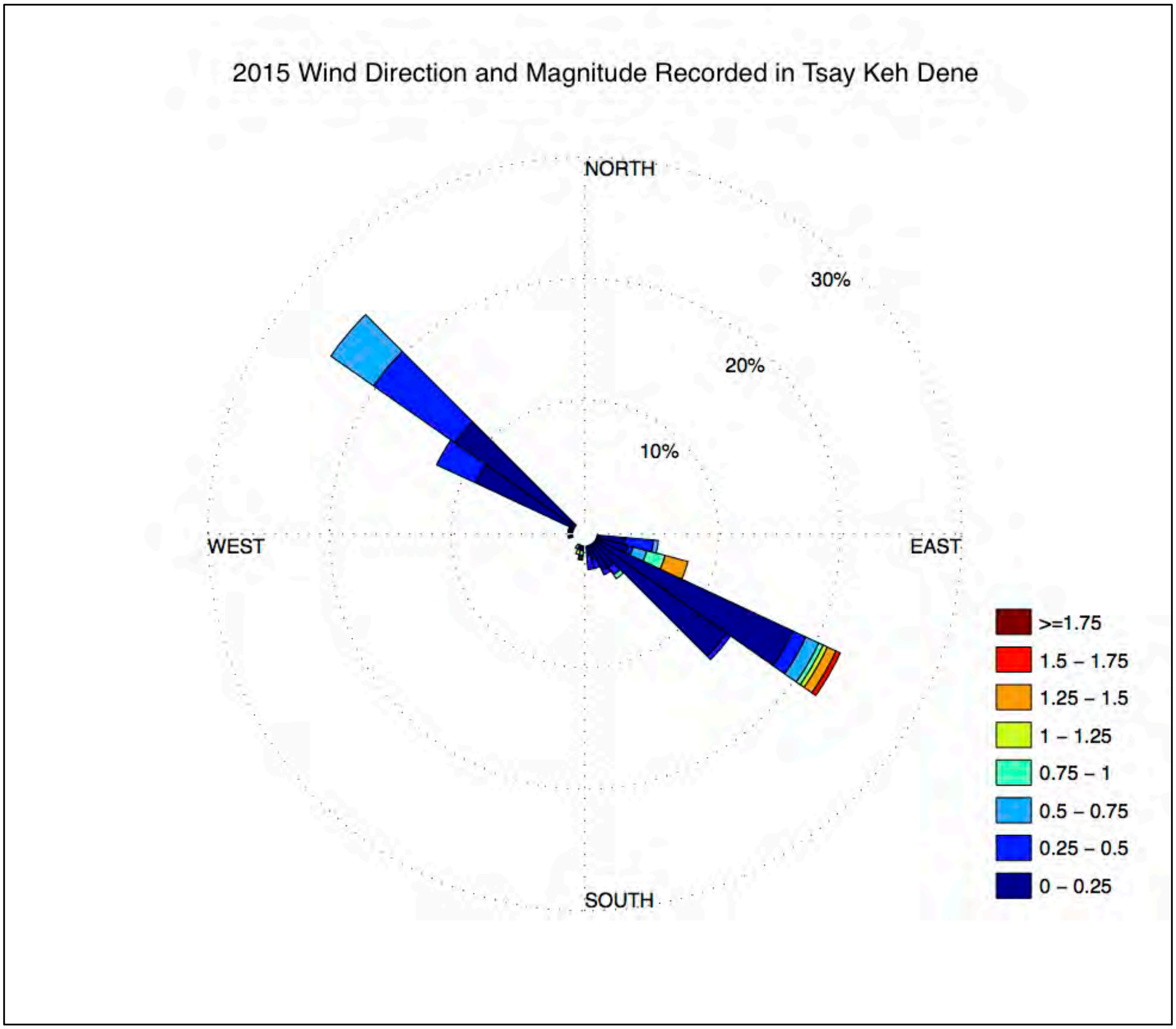


**Figure 33: Wind Rose Showing Wind Direction and Magnitude at the Tsay Keh Dene Monitoring Station**

### 3.2.2 Maximum Particulate Concentrations

Using the 24 hour metric for reporting air quality does not adequately represent the mode of air quality issues in Tsay Keh Dene because averaging tends to "smooth out" the extreme but short duration events that are typical of the air quality issues in Tsay Keh Dene.

All major dust activity in Tsay Keh Dene is derived from wind events that cause erosion on the beaches of the Williston Reservoir. These wind events are sporadic and vary greatly in magnitude, duration and frequency from one event to the next. As a result, these events may be highly localized and might persist for a short duration but the actual volume of dust emitted may be enormous. Under these conditions, calculation of a 24-hour average tends to minimize the actual impact of these acute dust events.

In this section we will evaluate the maximum recorded $PM_{10}$ and $PM_{2.5}$ concentrations between April 15th, 2015 and June 25th, 2015. To be clear, the following analysis is in no way meant to be compared to the Federal and Provincial air quality standards or objectives and the reference values are merely presented on the following figures in order to provide relative context.

Figure 34 shows the unfiltered and un-averaged $PM_{10}$ and $PM_{2.5}$ data recorded by the Tsay Keh Dene TEOM 1405-D. The brown dashed line in Figure 34 (b) represents a $PM_{10}$ reference value of 50 $\mu g/m^3$ while the green dashed line in Figure 34 (a) represents a reference value for $PM_{2.5}$ of 28 $\mu g/m^3$. These values are provided for reference only and are in no way meant to represent the provincial or federal air quality standards.

During the period inclusive of April 15th, 2015 and June 25th, 2015, there were a number of data spikes that represent large volumes of particulate entering the airspace around the TEOM 1405-D for a short period of time. The high intensity short duration data spikes are visible in Figure 34(a) and (b), which contains the raw un-processed 10-minute average TEOM 1405-D $PM_{10}$ and $PM_{2.5}$ data.

For the purposes of demonstrating the impact of the high frequency, high intensity, short-duration events that impact Tsay Keh Dene we have extracted the daily maximum value from the TEOM dataset for days where values exist that were above the arbitrary reference value of 50 $\mu g/m^3$ for $PM_{10}$ and 28 $\mu g/m^3$ for $PM_{2.5}$. These data are shown in Table 17 below. There are several instances where the $PM_{10}$ is in excess of 100 $\mu g/m^3$ and $PM_{2.5}$ value is above 40 $\mu g/m^3$. These values are just maximum recorded 10-minute concentrations for the given day, we have not provided an analysis that identifies the total amount of time that the TEOM was recording values in excess of the arbitrary reference values on these days.

Our project team would just like to reiterate that this analysis only meant to draw attention to the high frequency, high intensity, short-duration nature of the dust events in Tsay Keh Dene and is no way meant to be compared to the Federal or Provincial standards discussed above in Section 3.

**Table 17: Maximum 10-minute average $PM_{10}$ and $PM_{2.5}$ Values Recorded During the 2015 Dust Season in Tsay Keh Dene**

| Date | $PM_{10}$ Value ($\mu g/m^3$) | Date | $PM_{2.5}$ Value ($\mu g/m^3$) |
|---|---|---|---|
| 15-Apr-15 | 68.9 | 26-Apr-15 | 32.83 |
| 26-Apr-15 | 397 | 10-May-15 | 32.33 |
| 27-Apr-15 | 182.4 | 11-May-15 | 35.79 |
| 28-Apr-15 | 275.6 | 13-May-15 | 26.03 |
| 30-Apr-15 | 161.9 | 14-May-15 | 43.32 |
| 09-May-15 | 94.8 | 15-May-15 | 43.32 |
| 10-May-15 | 124.6 | 25-May-15 | 34.11 |
| 11-May-15 | 145.9 | | |
| 12-May-15 | 88.6 | | |
| 13-May-15 | 92.7 | | |
| 14-May-15 | 186.1 | | |
| 15-May-15 | 186.1 | | |

| | |
|---|---|
| 17-May-15 | 89.5 |
| 18-May-15 | 58.8 |
| 19-May-15 | 58.8 |
| 23-May-15 | 85.2 |
| 24-May-15 | 197.3 |
| 25-May-15 | 462.5 |
| 30-May-15 | 512.8 |
| 01-Jun-15 | 84.3 |

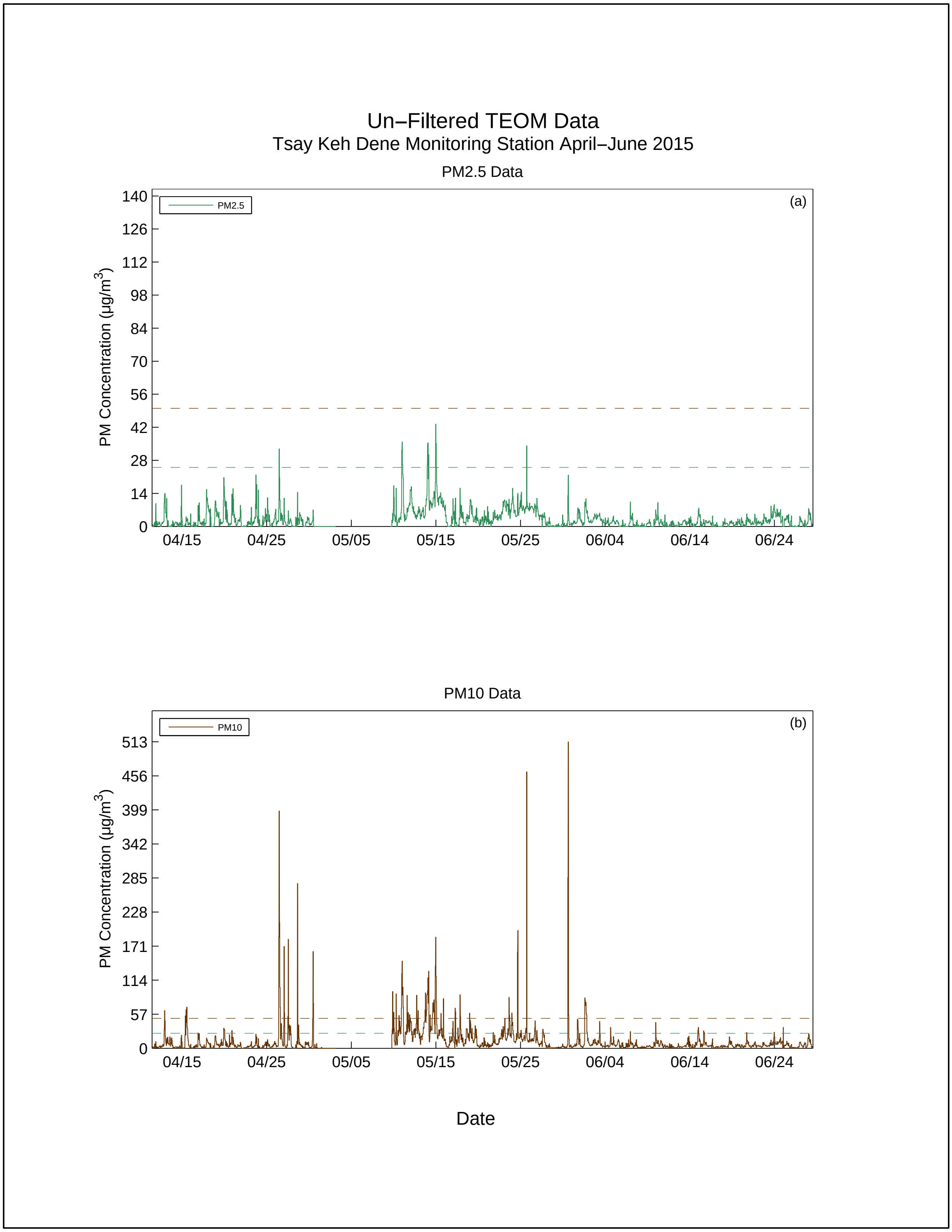


**Figure 34: Raw 10-Minute Average TEOM Data for the 2015 Dust Season.**

### 3.2.3 A Comparison of E-Sampler Data and TEOM Data

Since the E-Samplers do no carry a Federal Reference designation it is useful to provide a general comparison of E-Sampler and TEOM data in order to verify the abilities of the E-Sampler and to validate their use in this project. We will compare the data collected by the TEOM 1405-D to that collected by a co-located E-Sampler in Tsay Keh Dene over the same time period. The intake heads for both instruments are located at approximately 5 meters above the ground and are within 2 meters of each other.

Since the TEOM is recording $PM_{10}$ and the E-Sampler is recording TSP it is not meaningful to perform a simple numerical comparison such as a regression between the values. However, we can draw a great deal of meaning from a visual comparison of the time series plots of these data.

Figure 35 contains two charts showing both TEOM data and E-Sampler data. Keep in mind that the vertical y-axis scales are not comparable since they are different quantities. The x-axis scales for each of the sub-figures (Figure 35 (a) and (b)) are identical and the temporal response times are similar. Both instruments respond quickly and with similar relative magnitude to both large events and small dust occurrences.

In general this comparison should allow us to feel confident that the MetOne E-Sampler provide excellent data quality and is well suited to our regional monitoring program.

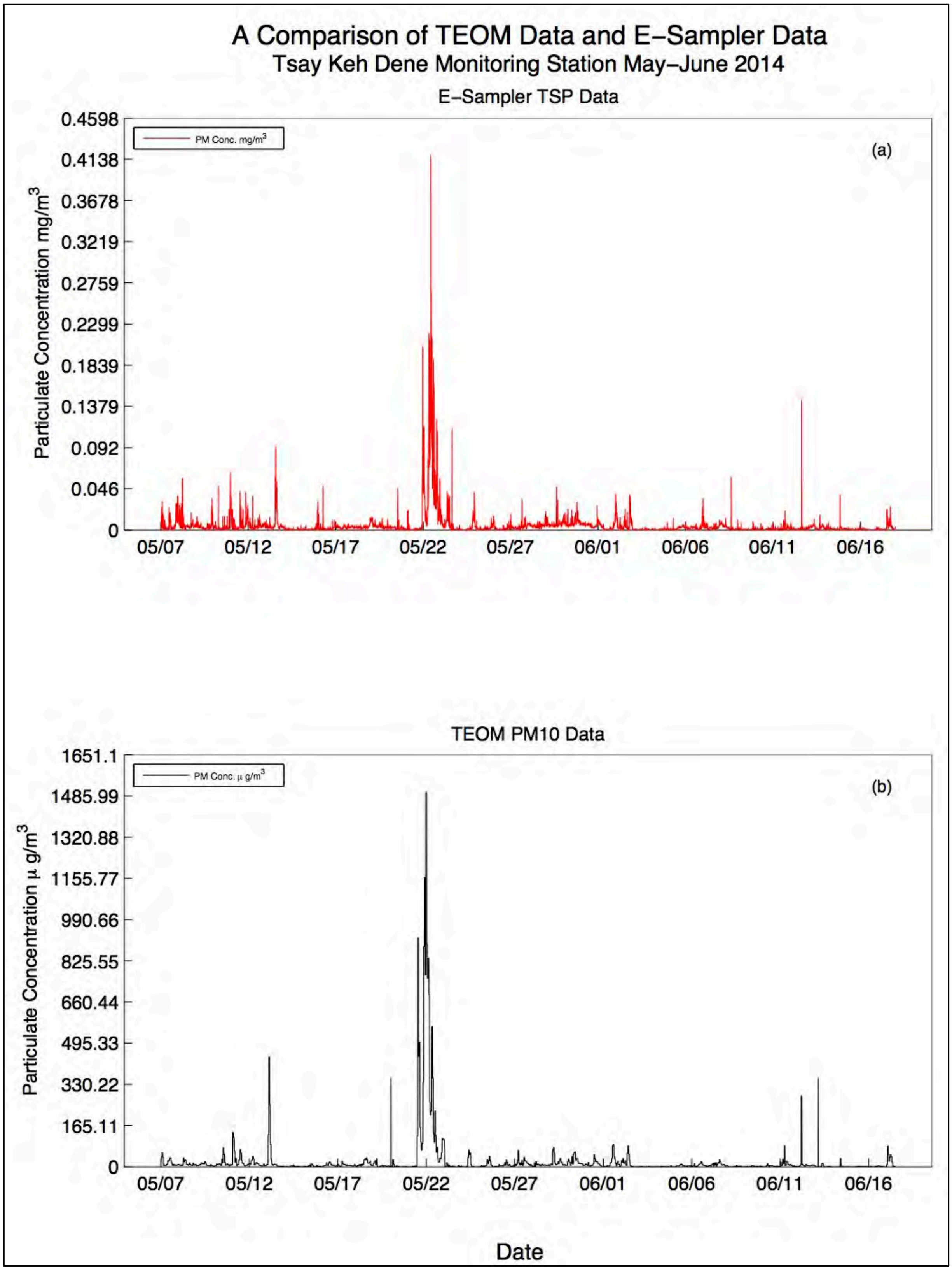


**Figure 35: A Time Series Comparison of 10-Minute Average TEOM 1405-D Data and 10-Minute Average E-Sampler Data**

### 3.2.4 Kwadacha Monitoring Station 24 Hour Average Air Quality and Meteorology Characterization

2015 data collected at the Kwadacha TEOM monitoring station are shown in Figure 36 (a) through (d). There were zero exceedences of the Provincial AQO for $PM_{10}$ and only a single exceedence of the Federal CAAQS for $PM_{2.5}$. On June 29th, 2015 the 24-hour average $PM_{2.5}$ concentration was 33.0 $\mu g/m^3$. It is highly unlikely that this event would be related to reservoir dust. Given the low average wind speed on June 29th, 2015 and lack of an associated $PM_{10}$ exceedence, this $PM_{2.5}$ exceedence is most likely related to woodsmoke from a nearby fire in the village.

Unfortunately this TEOM 1405-D suffered a debilitating circuit board failure on July 7th, 2015 and at the time of writing this report, remains un-repaired at the Thermo Scientific repair facility. Our project team has been given assurance that the unit will be repaired and returned in February 2016. This is a major upset to the continuity of the data collected at this station but is somewhat unavoidable when using TEOM 1405-D units as they are notoriously unreliable. For this reason many of the provincial monitoring stations were upgraded between 2010 and 2013 to the Thermo Sharpcut 5030, which is considered more reliable. The issue of reliability is exacerbated by the relative remoteness of Tsay Keh Dene and Kwadacha and the difficulty in rapidly accessing and repairing the equipment.

Average wind speed values in Kwadacha are lower than those recorded in Tsay Keh Dene and usually do not rise above 2.0 m/s. The barometric pressure sensor at Kwadacha failed in May 2015 but our project team was able to replace this unit with a spare in June 2015. Precipitation trends in Kwadacha were similar to Tsay Keh Dene with very low amounts through the spring and a sudden increase through the summer and fall.

## 3.3 Data System and Remote Access

Data from the TEOM units and associated meteorological equipment are accessed and displayed in several different ways. Our goal was to provide the highest level of data security and reliability by using multiple redundant systems that record, process, store and distribute the data. We are also looking at methods to continue to improve the ways in which people can view and interact with the data collected by the air quality monitoring network. To date, we have implemented the following system changes to improve connectivity, security and access:

**Community Data Display:**

Data are currently being streamed from the dataloggers using Campbell Scientific RF401 spread-spectrum 900 MHz radio transmitters and receivers. Campbell Scientific provides hardware and software that can be manipulated to display in real-time the data that are collected by the TEOM 1405-D and meteorological equipment. An omni-directional antenna that broadcasts the 900 MHz signal is mounted on the TEOM enclosure and is powered by the RF401. A second RF401 receiver unit equipped with a whip-antenna is attached to a laptop that is running Campbell Scientific's LoggerNet software. This computer is connected to a 32" TV that is wall-mounted in each band office. This system has proved extremely reliable, requiring only limited intervention to reset following system faults. We will continue to update the data display to keep it relevant and interesting.

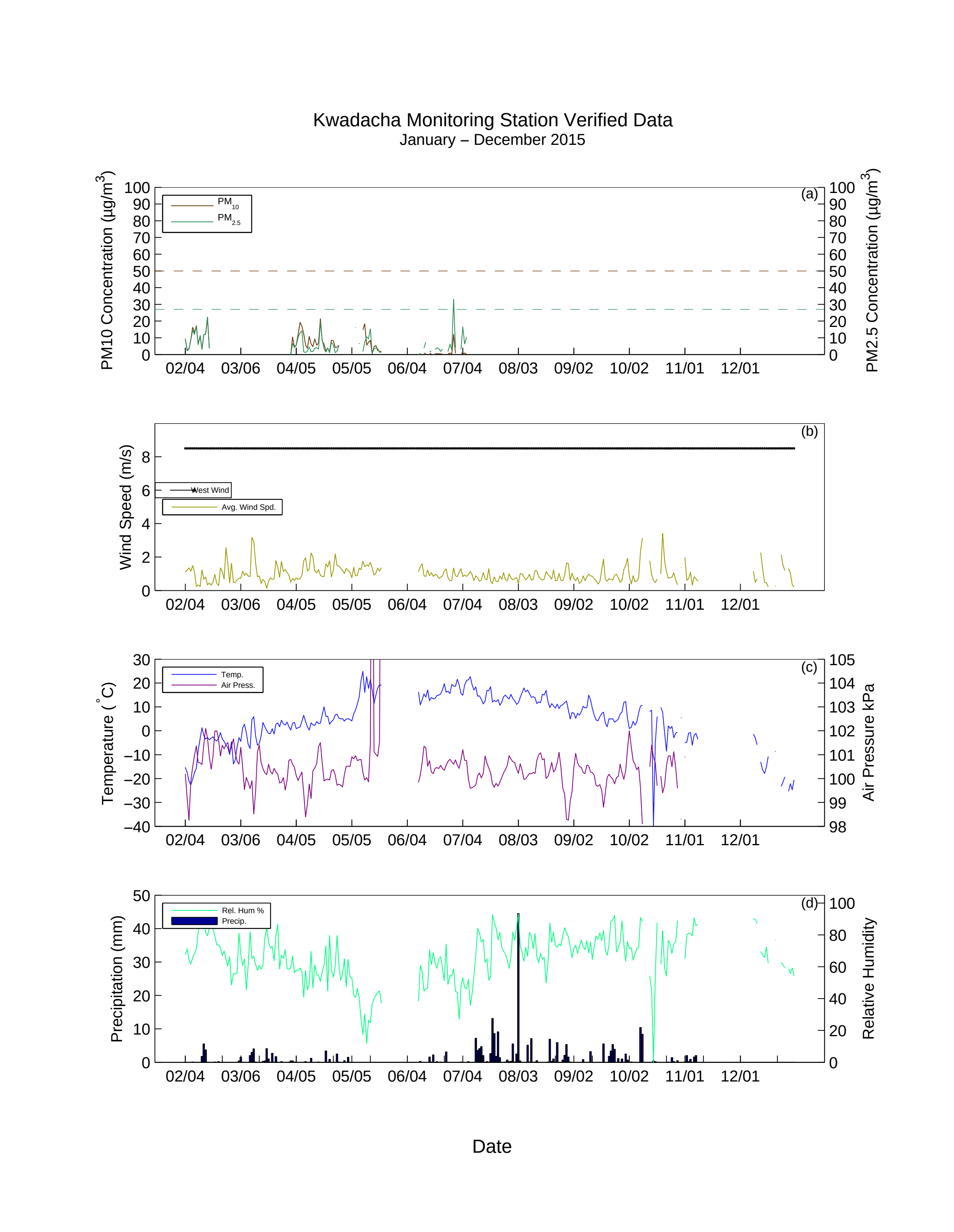


**Figure 36: Kwadacha TEOM Monitoring Station 2015 Annual Data**

**Eagle.io:**

All data are now available through a remote data access service called eagle.io. eagle.io is a web-based service that can access the data collected by the CR1000 datalogger through the Campbell Scientific NL200 Network Link Interface. eagle.io queries the NL200 for data every 10-minutes, collects that data and then updates the database and the website. These data are available online at the refresh interval and can be viewed in several different ways including a list view, map view, or a dashboard view that contains small widgets to show the data.

Each page is available on eagle.io and can be shared and viewed in a non-editable public profile by anyone who chooses to look. We will be updating our eagle.io profile in the coming months to take full advantage of the functions offered by eagle.io.

If there are readers who are interested in accessing these data, please consult info@chuchoenvironmental.com for more information.

**Daily email:**

Data from the CR1000 datalogger are downloaded over an RS-232 serial connection to a server computer located inside the TEOM enclosure. These data are processed into 10-minute averages and are then appended into 12-hour data files. After the processing is complete, the 12-hour data file is emailed to the project manager and field managers. Simultaneously the data are backed up to a system USB-key and are also uploaded the Chu Cho Environmental's ftp site. New for 2015 are a fourth and fifth layer of backup redundancy that includes a full system hard drive ghosting every 24 hours and a Dropbox backup of the key system and data files. If there is an issue with the data of if there is an issue with the TEOM of any of the meteorological instrumentation then a special email is sent out alerting the managers of the issue. This email provides a very quick way to check on the monitoring system to ensure that it is functioning properly.

**www.logmein.com:**

www.logmein.com provides remote desktop access to the server computers inside the TEOM enclosures. This is the most reliable method for creating remote access to these server machines that operate inside the VPN created by the Tsay Keh Dene IT group or Kwadacha IT group. This remote access allows us to reboot any component of the monitoring system and greatly improves our overall system reliability and up-time.

**Looking ahead:**

We will continue to look for ways to improve the overall reliability of the monitoring system and to create visuals that are more engaging and intuitive for people who are looking at and interpreting the data.

# 4.0 Dustfall Monitoring

Dustfall monitoring began in Spring 2014 in order to establish a baseline quantity for the volume of settleable particulate levels in the Tsay Keh Dene village area. Dustfall analysis is planned to take place from May to October for each year of this project, however in June of 2015 three of the project's dustfall stands were vandalized beyond repair or were thrown into the Williston Reservoir. We were able to retrieve samples from 2 of 3 samplers prior to the vandalism.

New stands were ordered and received in September of 2015. We will re-deploy and initiate the dustfall monitoring program again in 2016, however the stands will be moved to more obscure and hidden locations.

## 4.1 Equipment and Methodology

Dustfall sampling canisters prepared by ALS Environmental Laboratories were deployed at three locations in the vicinity of Tsay Keh Dene. The sample canister is a large 2 liter Nalgene bottle with a 4" diameter mouth that is open to the atmosphere. The sample canisters are opened, placed in a custom designed and built Dustfall stand and left alone to collect dust fallout for approximately 30 days.

Chu Cho Industries built the Dustfall stands according to design specifications supplied by EDI Environmental Dynamics Inc. Each Dustfall stand has a holder for the Nalgene canister that provides protection from cross winds and has vertical spikes welded on the rim of the wind guard to prevent birds from landing on the stand and contaminating the sample.

After approximately 30 days the sample canisters are removed, resealed and shipped to ALS Laboratories for gravimetric analysis. At this time, another canister is opened and placed in the Dustfall stand. The mouth of the sample canister is located as near as possible to 2 meters above the ground.

ALS Laboratories provides three values following the analysis: Fixed Dustfall, Volatile Dustfall and Total Dustfall. The volatile fraction is those particulates that are carbon based and therefore volatize when the sample is heated. Generally, for this project we are concerned with the Total and Fixed Dustall amounts since we know that the primary source of dust in TKD village is the reservoir beaches, which are comprised of silica based sands.

## 4.2 Network Characterization

Figure 37 shows the location of each sample site within Tsay Keh Dene village and relative to the reservoir. Table 18 provides a summary of the sampler ID, location and a site description. Each of the three samplers are shown in Figures 38 through 40.

**Table 18: Summary of Dustfall Monitoring Stations**

| Sampler ID | Location | Site Description |
|---|---|---|
| DF-TK-01 | Adjacent to TEOM | This site is very open and free from the influence of trees, |

| | | |
|---|---|---|
| | Monitoring Station | buildings or other impediments to flow. The sampler is located approximately 450m from the reservoir. |
| DF-TK-02 | Southern end of Tsay Keh Airport adjacent to a Finlay River cutbank. | This sampler is adjacent to the reservoir atop a cutbank where the Finlay River meets the Williston Reservoir across from Ruby Red Beach. There are no nearby trees, buildings or other impediments to airflow that would influence the sampler. |
| DF-TK-03 | Adjacent to a household in Tsay Keh village | This sampler is located in a sparsely wooded area adjacent to a household in Tsay Keh village. Airflow in the vicinity of the sampler is moderately influenced by the nearby woody vegetation but the sample canister does not collect pine needles or other falling organics. |

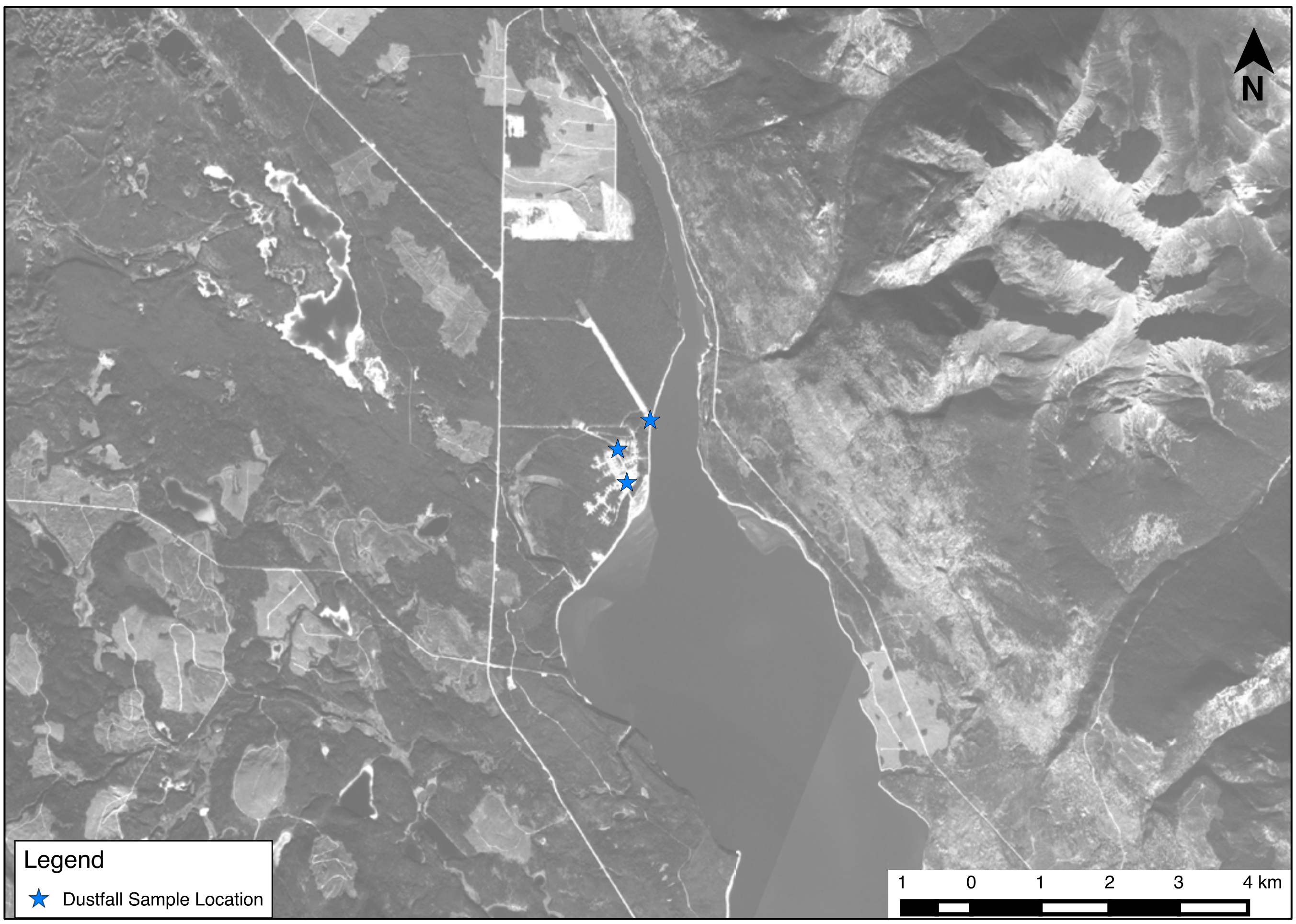


Figure 37: Tsay Keh Dene Dustfall Monitoring Network

Figure 38: DF-TK-01 Dustfall Sampler

Figure 39: DF-TK-02 Dustfall Sampler

**Figure 40: DF-TK-03**

## 4.3 Dustfall Analysis and Discussion

In British Columbia the lower dustfall AQO is 1.7 mg/dm$^2$*day while the upper AQO is 2.9 mg/dm$^2$*day (BC MoE, 2013). The upper limit was exceeded at DF-TK-03 during May 2015.

**Table 19: Dustfall Monitoring Network Summary Data**

| Site ID | Sample Date | Month | Fixed DF | Volatile DF | Total DF | Units | Det. Limits |
|---|---|---|---|---|---|---|---|
| DF-TK-01 | 2015-06-09 | May | 1.29 | 0.37 | 1.66 | mg/dm$^2$*day | 0.1 |
| DF-TK-03 | 2015-06-09 | May | 2.28 | 0.67 | 2.95 | mg/dm$^2$*day | 0.1 |

# 5.0 Ancillary Objectives

In addition to providing the management services required to operate the air quality monitoring systems, Chu Cho Environmental built a program centered on capacity building, knowledge transfer and community engagement. This program is focused on mentorship and skills development within Tsay Keh Dene band members and is also meant to provide a link between community members and the science of the Williston Dust Mitigation Program.

## 5.1 Mentorship Program

In our mentorship program we utilize a process of employee self evaluation and management evaluation of employees to monitor metrics in the form of Key Performance Indicators (KPIs) such that each employee can track their success and growth as an environmental monitor and in particular an air quality technician. The metrics that we use as guidelines include but are not limited to the following:

- Worker is able to fully download the data and recalibrate the instrument on their own.
- Worker is able to diagnose problems and develop, record and communicate a working solution in the field.
- Worker is able to make, record and communicate management decisions in the field.
- Worker is careful, thoughtful and thorough with regards to scientific issues.
- Worker is always safe.
- Worker always makes unbiased decisions with regards to the scientific process.
- Worker makes good field notes with clear observations and records that are both relevant and important.
- Worker is competent with a field computer for data capture and storage.
- Worker is developing a sense of confidence with regards to program tasks and knowledge about air quality.
- Worker is sensitive to QA/QC issues and takes great pride and care in ensuring that the instrumentation is always functioning properly and with proper calibration requirements.

We at Chu Cho Environmental recognize that it is our responsibility and commitment to provide an open and communicative work environment in order to cultivate success and growth within our employees. We also utilize a number of non-specific personality metrics in order to evaluate the overall confidence and aptitude growth of our employees. To date we achieved exceptional growth in knowledge and confidence within four of our employees and we expect continued growth through the future of this project.

Chu Cho Environmental now has full-time employees in Kwadacha and Tsay Keh Dene who are able to autonomously manage the basic maintenance and operation of the Air Quality Monitoring Stations. These employees possesses a rudimentary understanding of how the instrument functions and what normal operation should entail. When a major issue is encountered, the employees alert the Chu Cho Environmental project manager immediately and the problem is rectified as soon as possible. Due to the remoteness of the TEOM monitoring stations and the difficulty in maintaining a reliable internet connection to the machine, it is imperative to have well trained local employees who can frequently visit the instrumentation to ensure proper operation. This has been one of the greatest improvements in our program and has contributed to our overall success in reducing instrument downtime.

## 5.2 Community Engagement

Chu Cho Environmental is a band owned company and regularly participates in community events such as open houses or village gatherings where the exchange of information is encouraged between community members and organizations. We do not present unverified air quality data at these events but instead provide visuals and information related to the project and what we are doing to monitor and help improve the air quality in Tsay Keh Dene.

Chu Cho Environmental also built community data displays that are presented on TVs that are wall-mounted in the Tsay Keh Dene band office and the Kwadacha school. The data are broadcast in real-time from the TEOM enclosure using an RF401 900 Mhz spread spectrum radio transmitter and are received on an RF 401 that is attached to a computer which runs the TV data display. Figures 44 through 46 show sample screen grabs of the data display, note that there is no live data shown in these images. These displays are meant to be easy to read at a glance and will continue to be updated and refined as Chu Cho Environmental continues to manage the project. The data area broadcast from the monitoring station at the same frequency as they are being recorded by the CR1000 data logging system, this means the weather data are updated every 10 seconds and the air quality data are updated every 10 minutes.

This method of displaying the data is quite reliable but ultimately depends on a PC laptop running Windows 7 and so suffers crashes related to operating system failure. Maintaining and rebooting this system has also been incorporated into the training of the technicians who maintain the TEOM monitoring stations.

The new data display system includes the following major updates:

- More intuitive screen widgets to display the data,
- A “Last Data Update” timestamp that shows when the data were received,
- High quality graphics and visuals that are nice to view, and
- High frequency and increased reliability link to the data source.

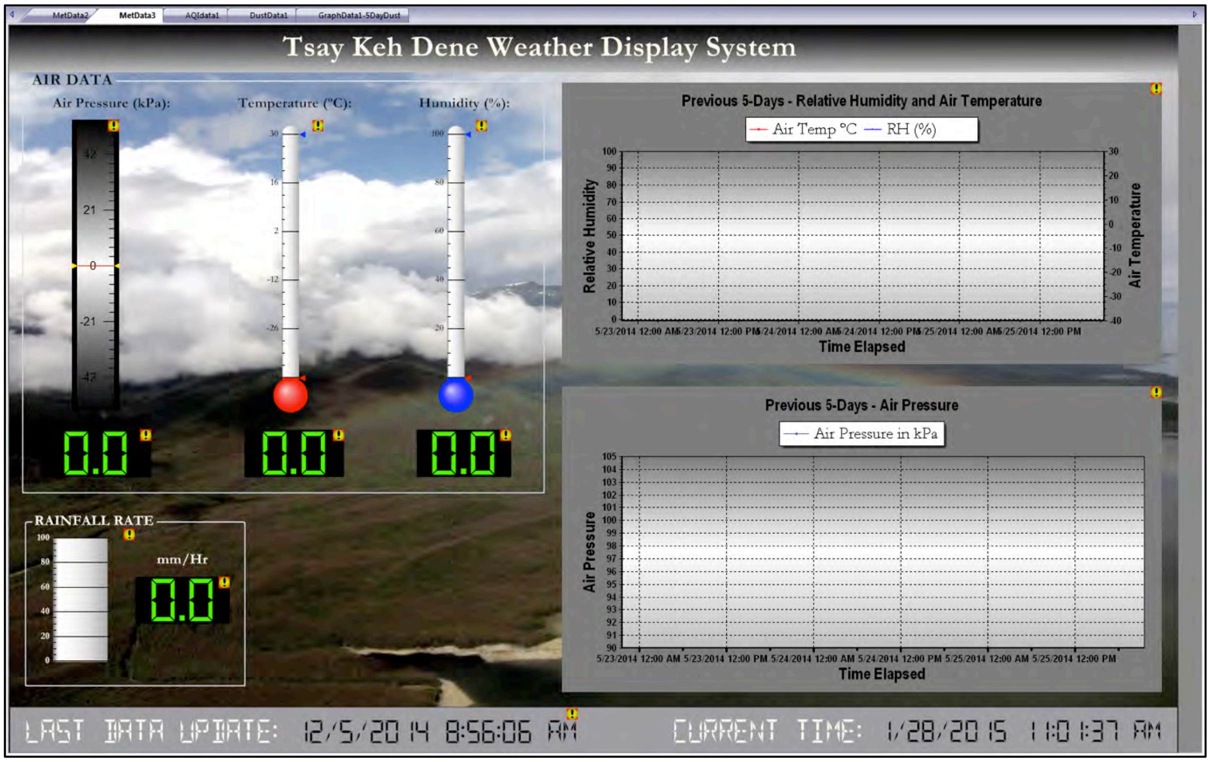


Figure 41: Data Display Air Parameters and 5-Day Charts

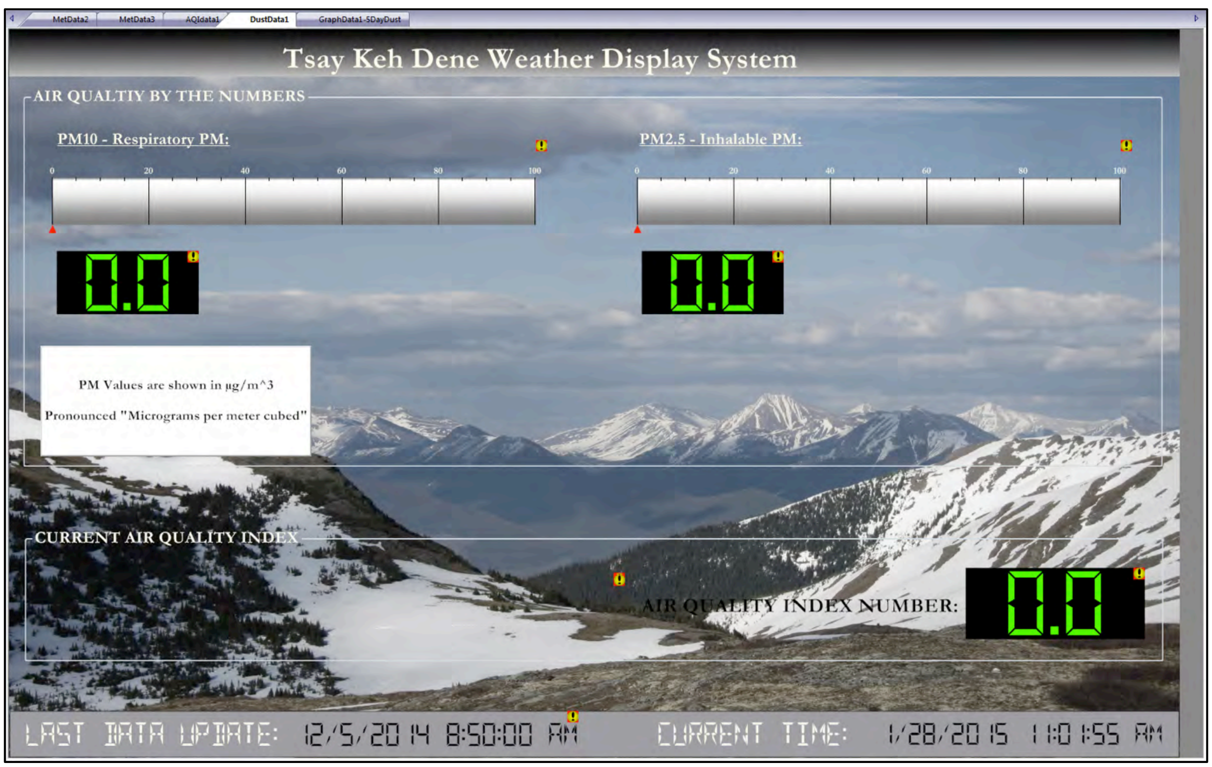


Figure 42: Data Display Air Quality Data and Air Quality Index

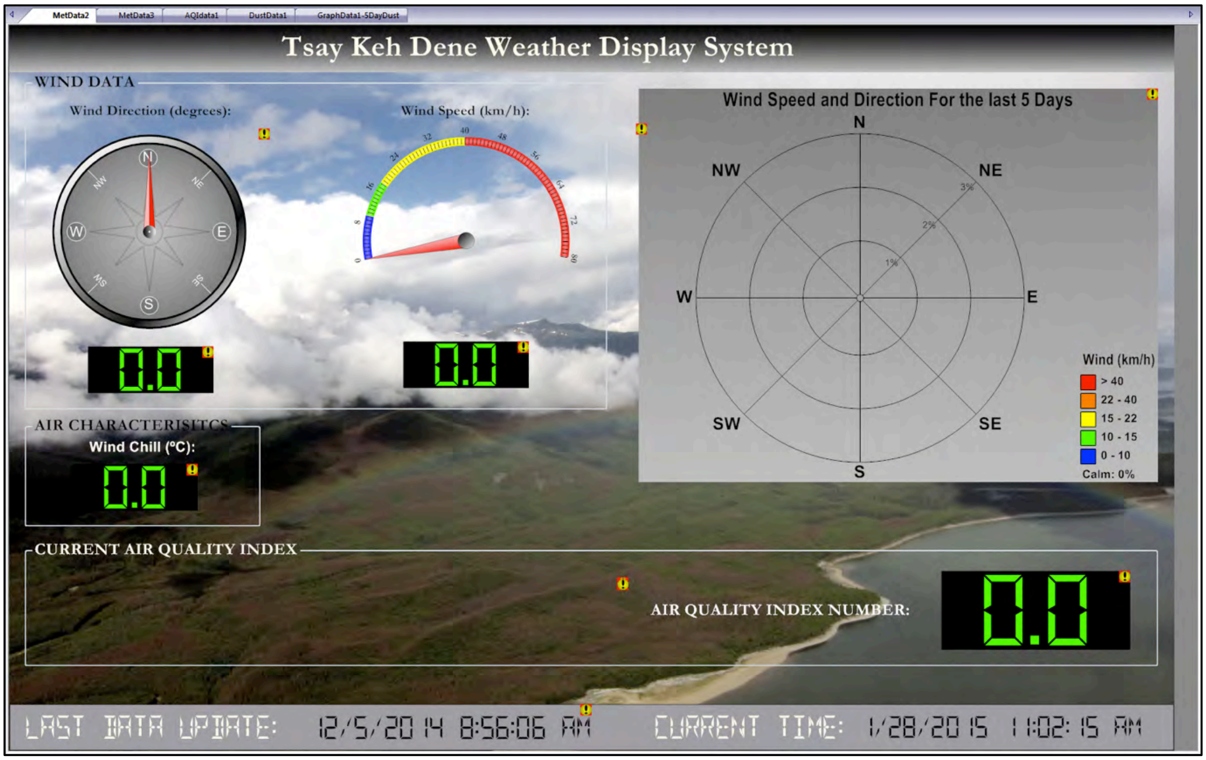


Figure 43: Data Display Wind Parameters and 5-Day Wind Rose

# 6.0 Discussion and Direction for 2016

## 6.1 Brief Summary for 2015

Through discussion with BC hydro representatives it was determined that Chu Cho Environmental would submit an annual report in January of each year. This report will be reviewed internally by BC Hydro and the edits will be delivered to Chu Cho Environmental by March of each year. Following this Chu Cho Environmental will update and revise the report and will issue a final version by April of each year.

Each of the annual reports prepared by Chu Cho Environmental should ultimately be considered individual annual building blocks that will lead up to a comprehensive 10-year analysis report that will be prepared in 2017/2018.

It is our hope that through the review and revision process that we will gain insight into these data and will discover new perspectives through which to analyze these data, which will ultimately help our project team provide reasonably powerful answers to the key management question of GMSMON#18.

Overall, 2015 was a successful year for Chu Cho Environmental and the GMSMON#18 project. Our team has continued to collect an enormous volume of data that industry air quality experts (modelers in particular) have deemed unparalleled and unique. Unfortunately, 2015 was not a particularly dusty year and so did not sufficiently advance our understanding of the impact of mitigation activities.

The primary finding presented somewhat repeatedly throughout this report is that dust storms are not discrete long duration events that always result in the exceedence of Federal and Provincial standards. Instead we must think of dust events as having dynamic impacts and a range of characteristics. Dust events can range in scale from isolated very short duration microburst type occurrences to very large, very long mega events.

There are several areas throughout the reservoir that show regular and repeated incidences of fugitive dust emissions. These locations are the so-called "hot spots" and are likely good candidates for erosion control targeting.

Chu Cho Environmental would like to remind the reader that the analysis and conclusions presented in this report represent a very preliminary approach to examining the enormous amount of data collected by the monitoring networks. In 2015, our analysis procedures were streamlined so that we were able to collect data immediately following an event and could have the data analyzed and reduced shortly after. Creating the database and algorithms required to perform these analyses is time consuming but well worth the effort.

## 6.2 Direction for 2016

The following summary topics comprise a list of tasks and analysis procedures that we plan to incorporate into GMSMON#18 and future iterations of this report:

## Winter 2016 Deployment:

Prior to 2015, air monitoring equipment was typically deployed during the first and second week of May. However, we know that there are early season dust events that occur prior to May when the beaches are exposed in April. The major impediment to setting equipment up earlier has always been snow cover and site access. For the 2015 season, Chu Cho Environmental rented two snowmobiles and a 6-seat Polaris Ranger on tracks, see Figure 47. This allowed us to successfully complete a full system setup by April 7th, 2015. We will continue this initiative in 2016. This early season setup is only made possible by the relatively high operating autonomy of the E-Samplers.


**Figure 44: 2015 Winter Setup Crew and Equipment**

## Future Data Analysis:

*Event Magnitude and Response in TKD:*

- In 2014 we extended the heatmapping analysis excise to evaluate the processes of dust events that migrate throughout the reservoir and the associated responses of the air monitoring instrumentation throughout the Finlay Valley. For example, it was demonstrated that the May 20th, 2014 storm arrived at the southernmost samplers several hours before arriving in TKD. Moving forward we will work to isolate these events types so that we might fully understand the ways in which the storms develop and how the various confounding variable affect evolution of an event.

*Dust Emissions Before and After Tillage:*

- We have analyzed two years data attempting to evaluate the response of the E-Samplers both before the application of tillage and following the application of tillage. Although our dataset is limited we have begun to see some emerging trends.

- We will continue to evaluate the E-Sampler data from this perspective to help constrain these data and provide a much needed more rigorous analysis here. It is absolutely imperative moving forward that we incorporate the numerous confounding variables into our model for evaluating dust concentrations before and after tillage. We are currently engaged in this process and will provide periodic updates.

*E-Sampler Flux Analysis:*

- We will begin to evaluate the flux of sediment that passes the point of sampling for a given wind speed. This will provide the ability to discuss dust concentrations in real terms so that we are able to estimate the approximate volume of dust that enters and exits a particular reservoir zone.

*Isolating the impact of reservoir rise from mitigation efforts:*

- We have begun examining the rate of reservoir rise and the associated rate of beach inundation and how this relates to dust concentrations recorded by the regional monitoring network. We are currently working on a method to isolate the effect of mitigation treatments from the rate of beach inundation.

- Currently, we know that on any given day the rate of beach inundation has the potential to exceed the rate of tillage application by approximately 4 to 10 times depending on the water elevation. Ultimately this means that the treatable area could disappear very quickly and that we should evaluate our mitigation strategies to ensure that we are meeting the highest possible efficacy over the long term.

*Rigorous Statistical Analyses:*

- As we continue to collect more data we will be able to begin to focus on the issues from a long-term trend and statistical perspective. Moving forward we will incorporate advanced regression and statistical models into our reporting.

# 7.0 References

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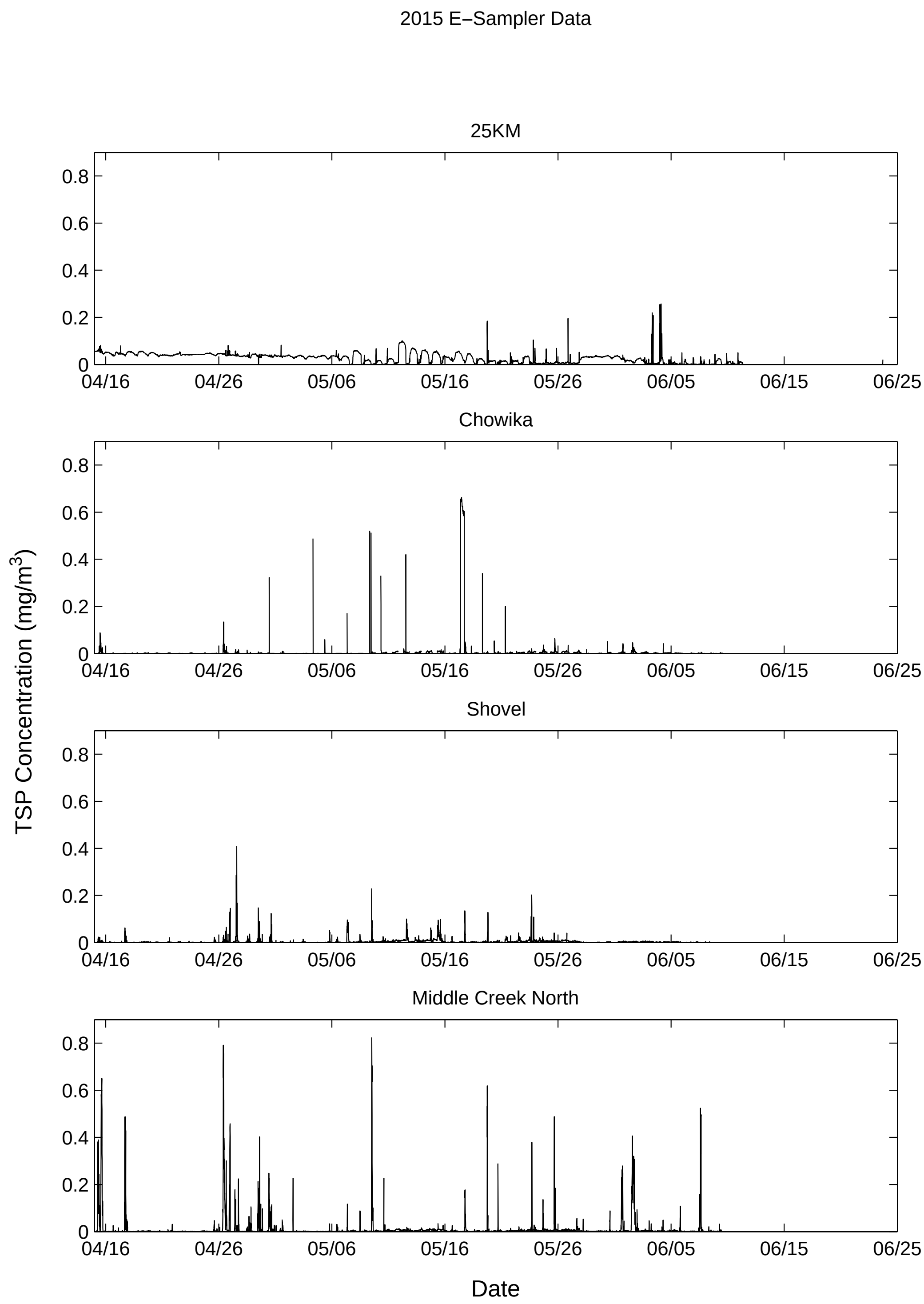
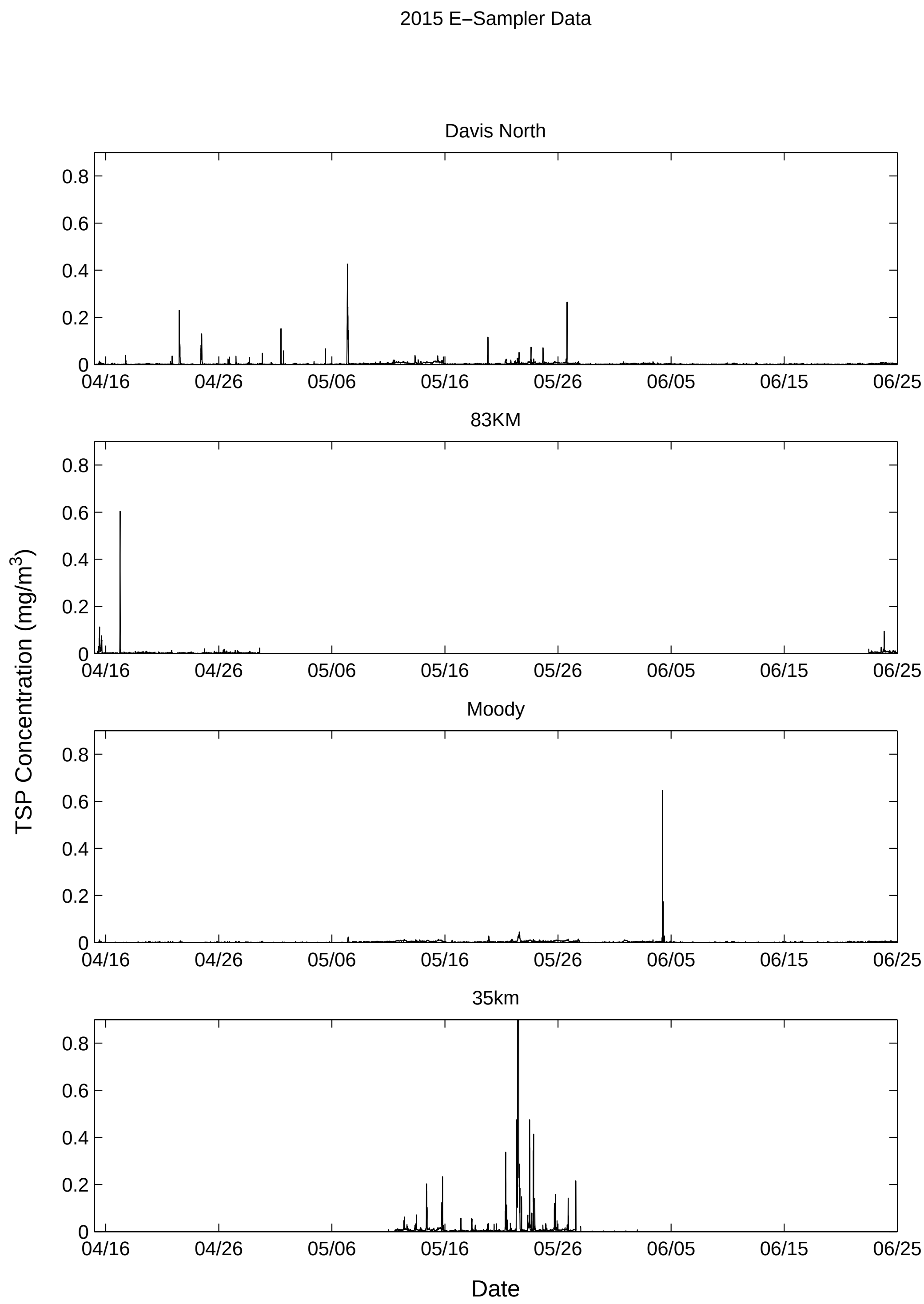
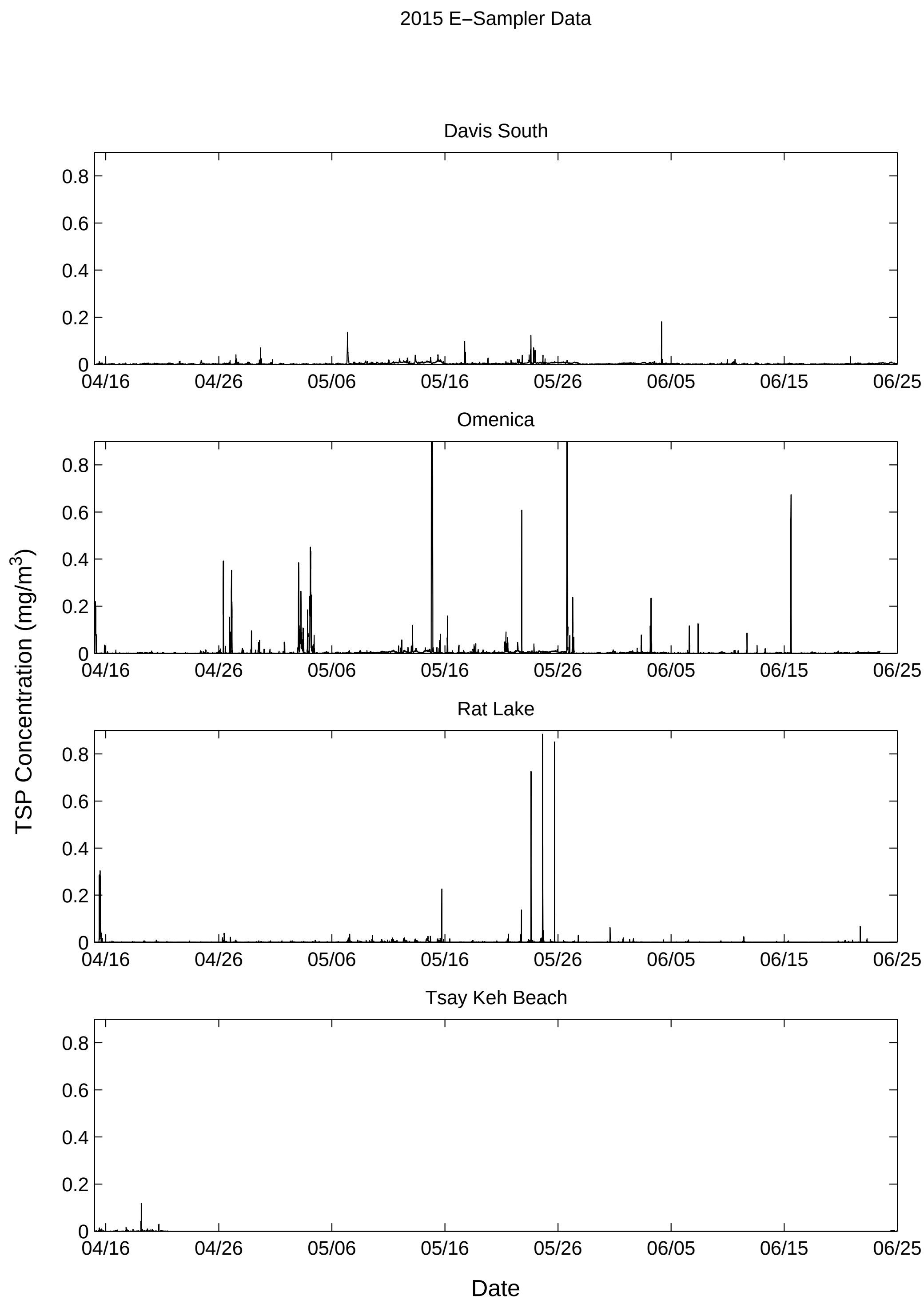
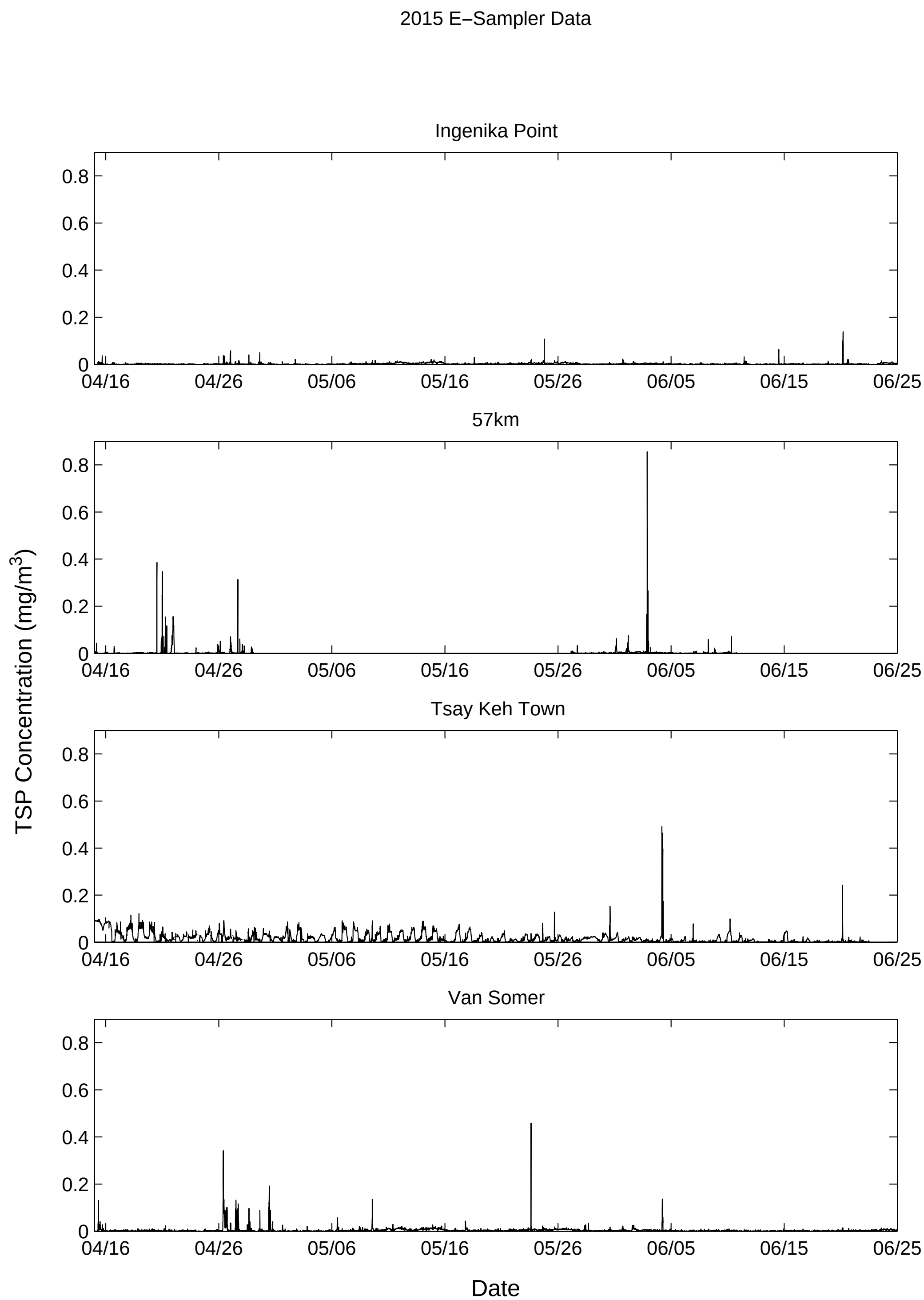
W G Nickling, J A Gillies, G Nikolich, and S McKeown. Williston dust control monitoring: BC hydro williston reservoir air monitoring report 2013. Report, British Columbia Hydro, 2013.

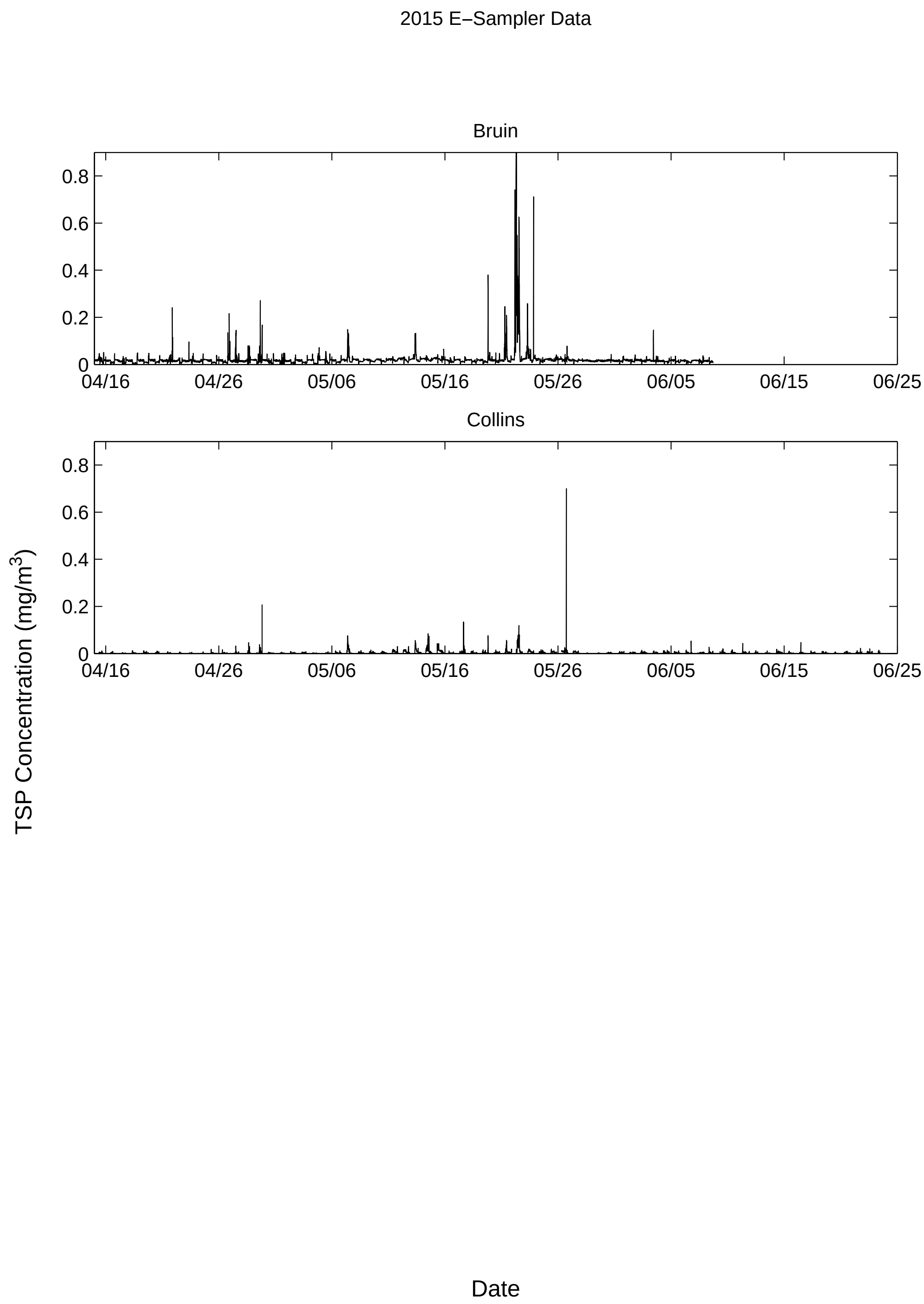
# APPENDIX A E-SAMPLER TEMPORAL DATA


2015 E−Sampler Data
25KM
Chowika
Shovel
Middle Creek North
TSP Concentration (mg/m3)
Date
0
0.2
0.4
0.6
0.8
04/16
04/26
05/06
05/16
05/26
06/05
06/15
06/25

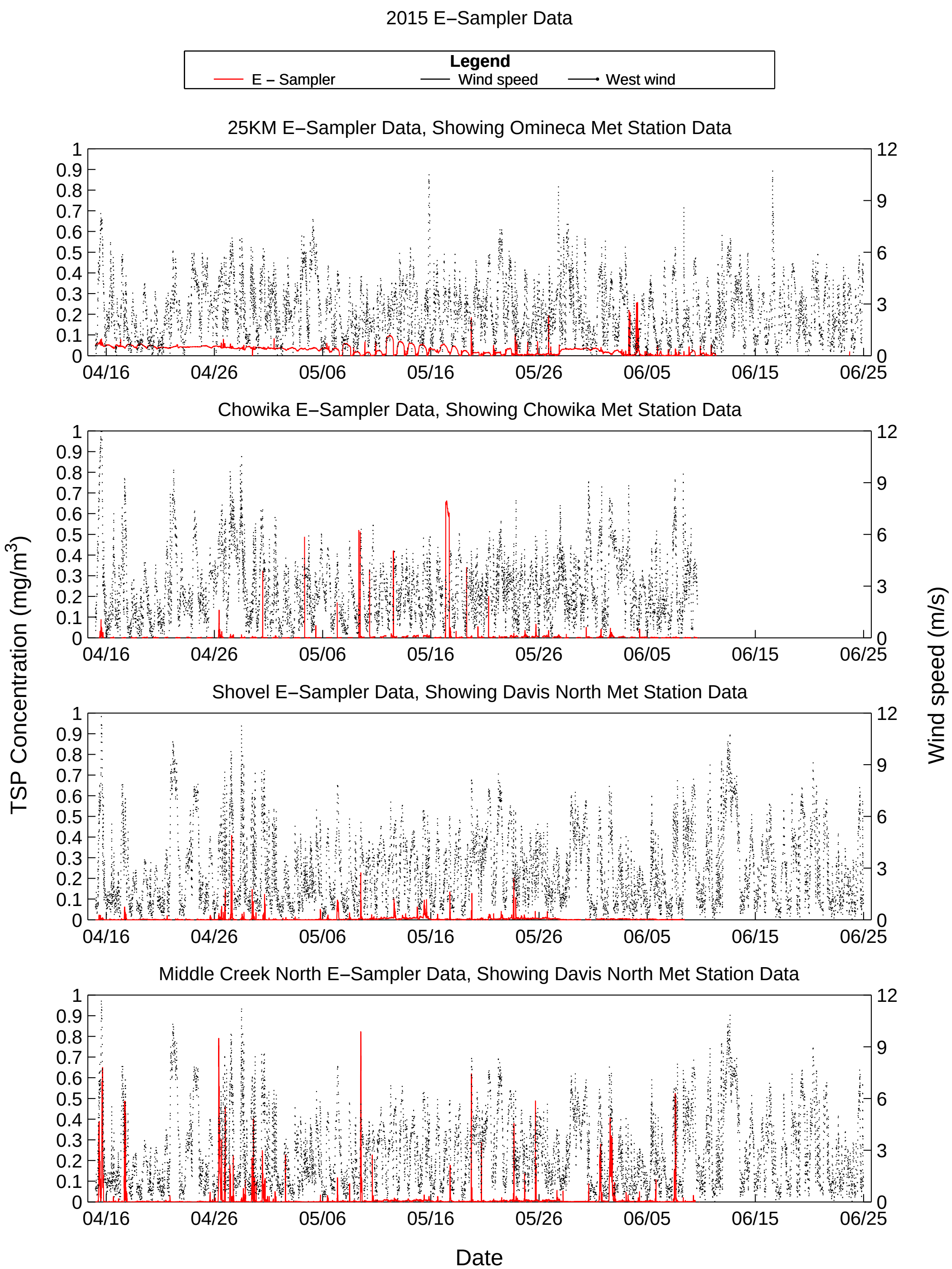

2015 E–Sampler Data
Davis North
83KM
Moody
35km
TSP Concentration (mg/m3)
0
0.2
0.4
0.6
0.8
04/16
04/26
05/06
05/16
05/26
06/05
06/15
06/25
Date

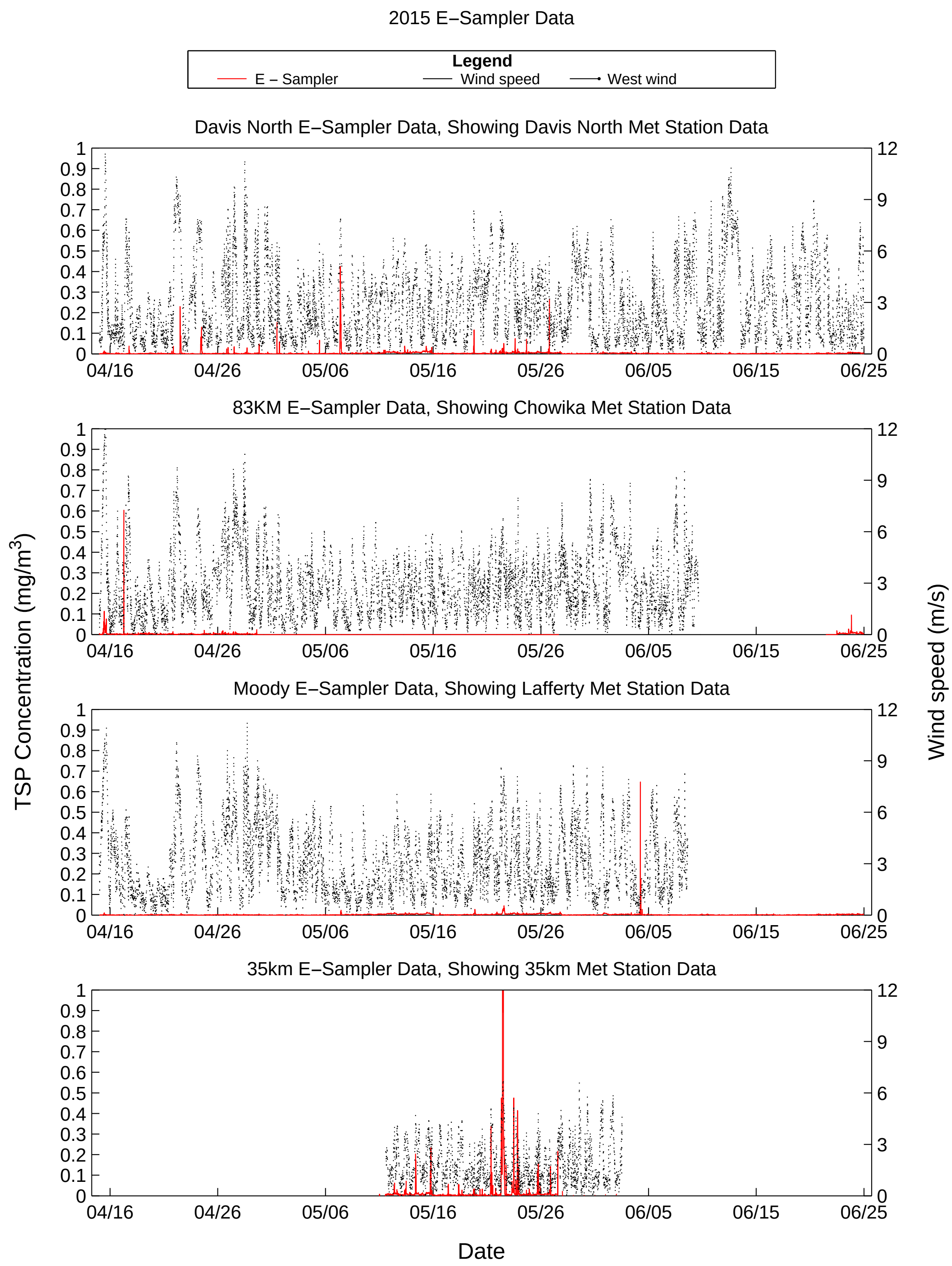

2015 E–Sampler Data
Davis South
Omenica
Rat Lake
Tsay Keh Beach
TSP Concentration (mg/m3)
0.8
0.6
0.4
0.2
0
04/16
04/26
05/06
05/16
05/26
06/05
06/15
06/25
Date

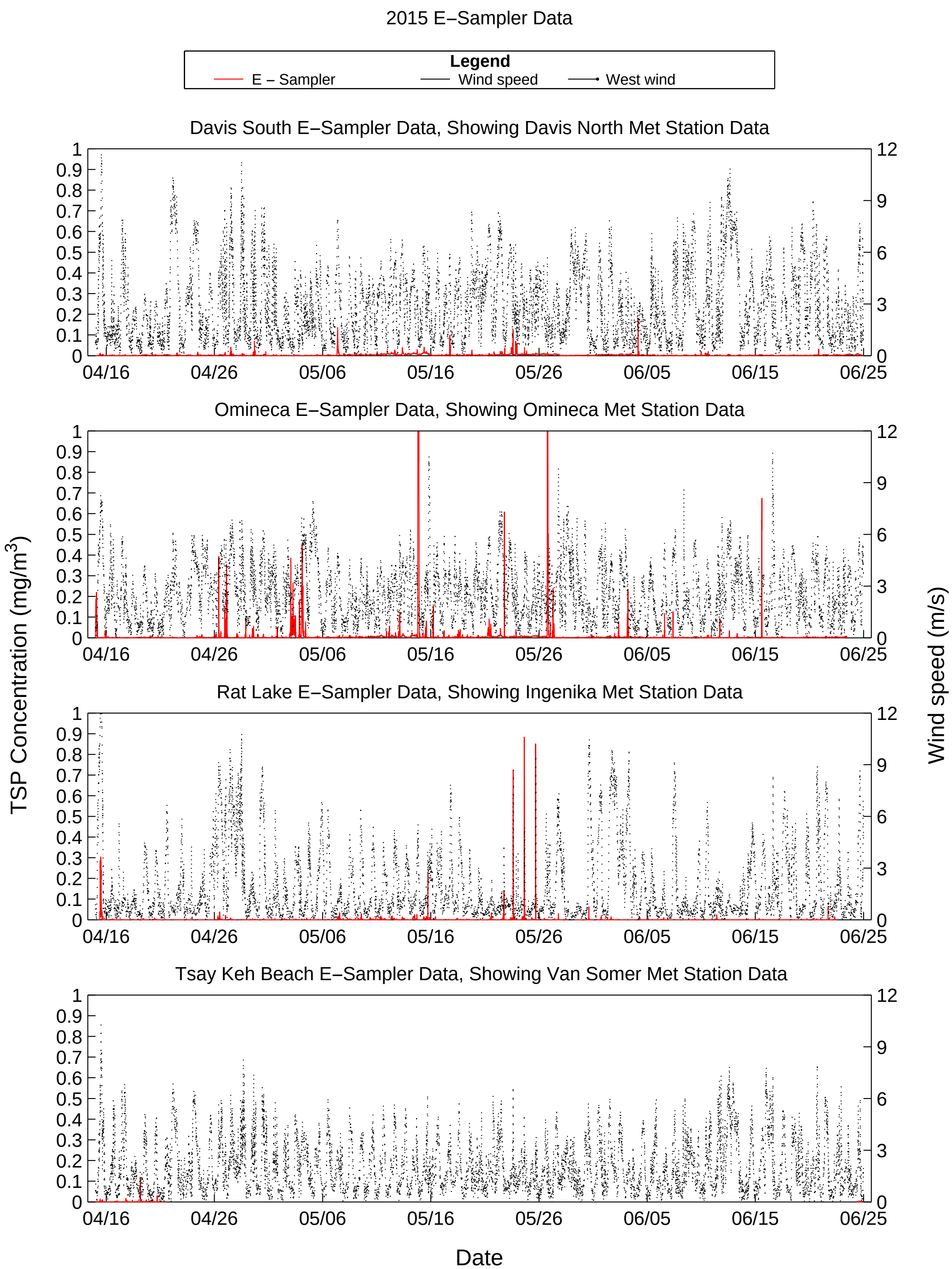

2015 E−Sampler Data
Ingenika Point
57km
Tsay Keh Town
Van Somer
TSP Concentration (mg/m3)
0
0.2
0.4
0.6
0.8
04/16
04/26
05/06
05/16
05/26
06/05
06/15
06/25
Date

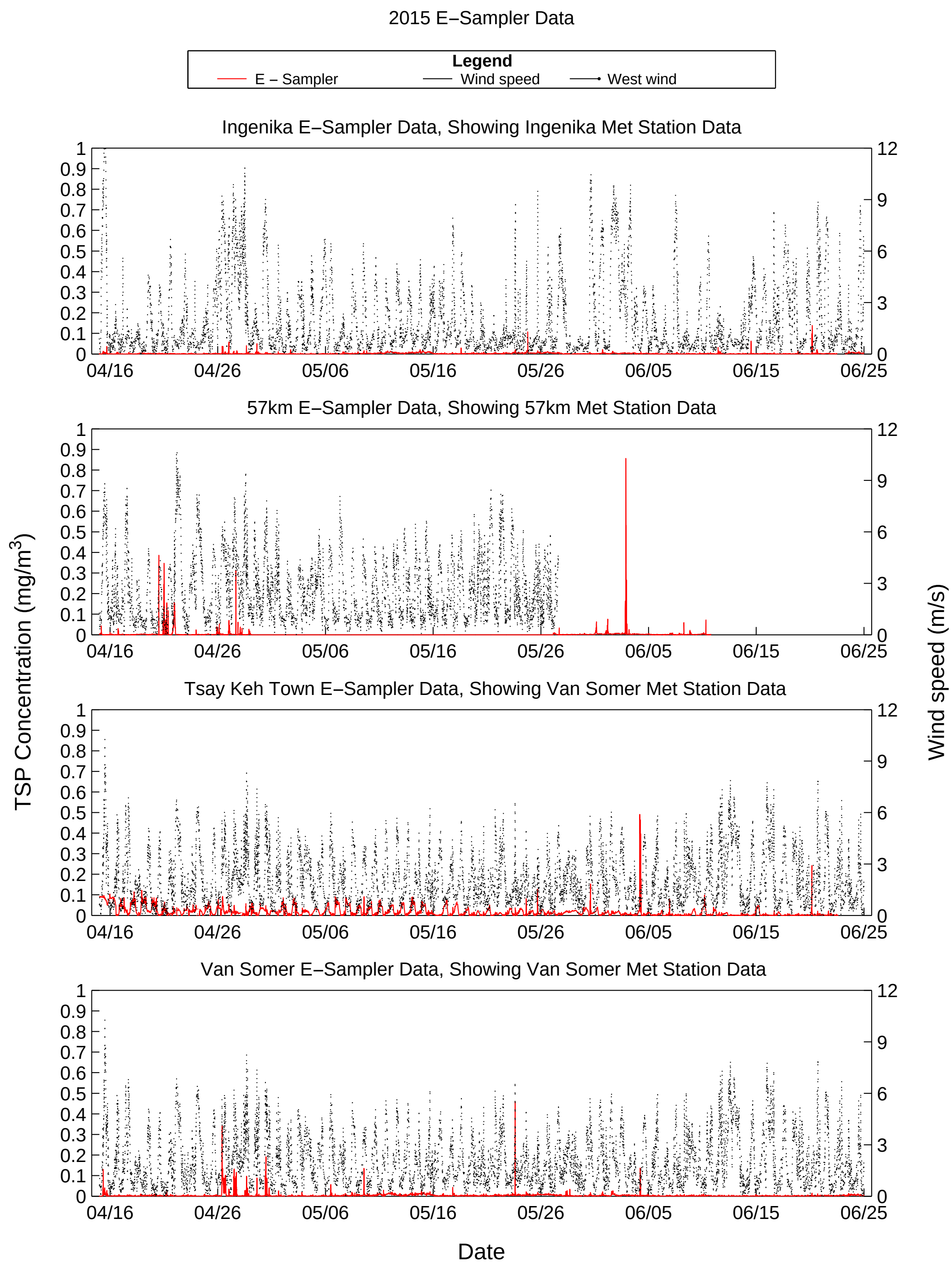

2015 E–Sampler Data
Bruin
0.8
0.6
0.4
0.2
0
04/16
04/26
05/06
05/16
05/26
06/05
06/15
06/25
Collins
0.8
0.6
0.4
0.2
0
04/16
04/26
05/06
05/16
05/26
06/05
06/15
06/25
TSP Concentration (mg/m3)
Date

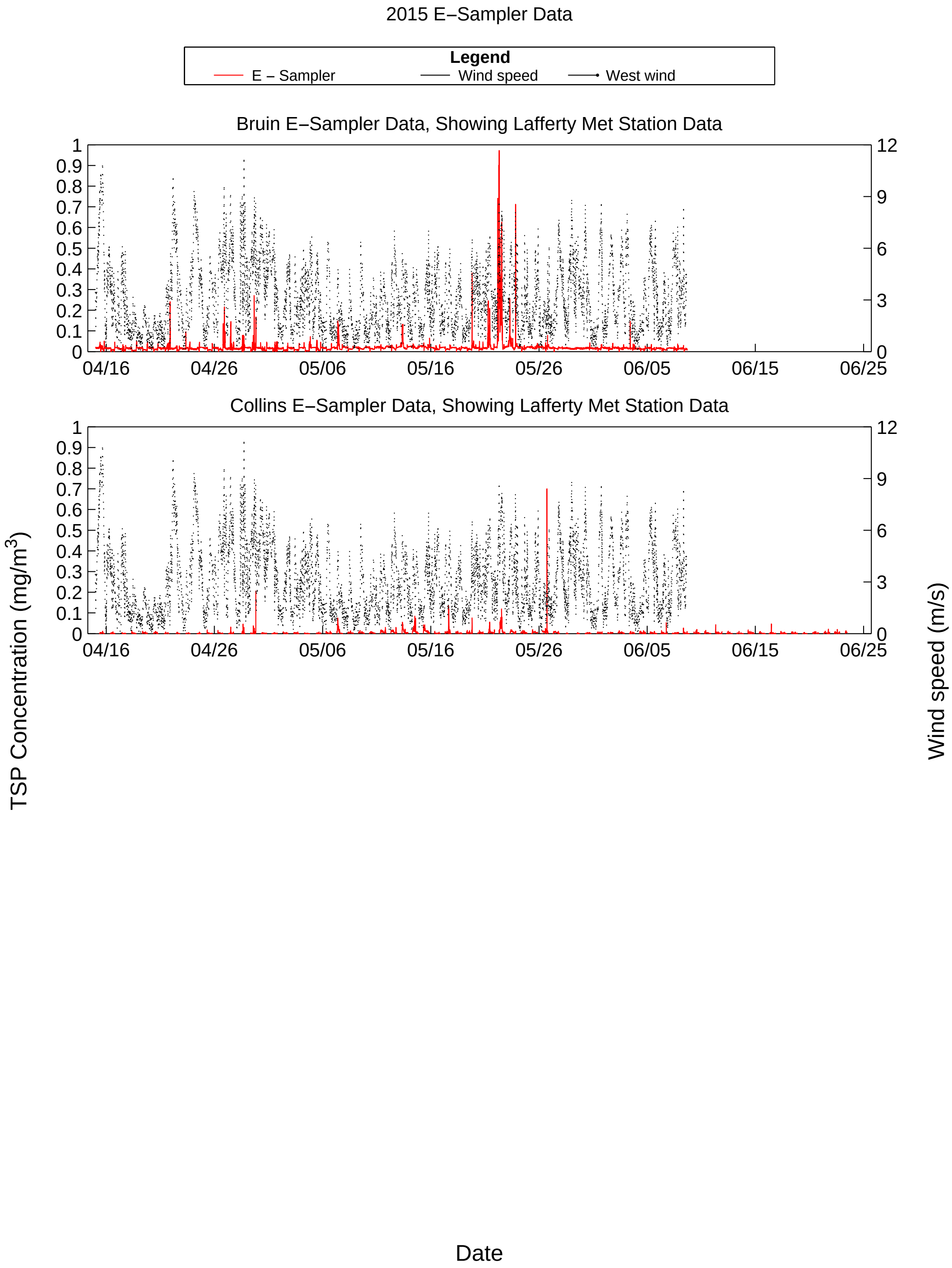
# APPENDIX B E-SAMPLER DATA OVERLAYED WITH WIND SPEED


2015 E–Sampler Data
Legend
E – Sampler
Wind speed
West wind
25KM E–Sampler Data, Showing Omineca Met Station Data
Chowika E–Sampler Data, Showing Chowika Met Station Data
Shovel E–Sampler Data, Showing Davis North Met Station Data
Middle Creek North E–Sampler Data, Showing Davis North Met Station Data
TSP Concentration (mg/m3)
Wind speed (m/s)
Date
04/16
04/26
05/06
05/16
05/26
06/05
06/15
06/25


2015 E–Sampler Data
Legend
E – Sampler
Wind speed
West wind
Davis North E–Sampler Data, Showing Davis North Met Station Data
83KM E–Sampler Data, Showing Chowika Met Station Data
Moody E–Sampler Data, Showing Lafferty Met Station Data
35km E–Sampler Data, Showing 35km Met Station Data
TSP Concentration (mg/m3)
Wind speed (m/s)
Date
04/16
04/26
05/06
05/16
05/26
06/05
06/15
06/25


2015 E–Sampler Data
Legend
E – Sampler
Wind speed
West wind
Davis South E–Sampler Data, Showing Davis North Met Station Data
Omineca E–Sampler Data, Showing Omineca Met Station Data
Rat Lake E–Sampler Data, Showing Ingenika Met Station Data
Tsay Keh Beach E–Sampler Data, Showing Van Somer Met Station Data
TSP Concentration (mg/m3)
Wind speed (m/s)
Date
04/16
04/26
05/06
05/16
05/26
06/05
06/15
06/25


2015 E–Sampler Data
Legend
E – Sampler
Wind speed
West wind
Ingenika E–Sampler Data, Showing Ingenika Met Station Data
57km E–Sampler Data, Showing 57km Met Station Data
Tsay Keh Town E–Sampler Data, Showing Van Somer Met Station Data
Van Somer E–Sampler Data, Showing Van Somer Met Station Data
TSP Concentration (mg/m3)
Wind speed (m/s)
04/16
04/26
05/06
05/16
05/26
06/05
06/15
06/25
Date


2015 E–Sampler Data
Legend
E – Sampler
Wind speed
West wind
Bruin E–Sampler Data, Showing Lafferty Met Station Data
Collins E–Sampler Data, Showing Lafferty Met Station Data
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
12
9
6
3
0
04/16
04/26
05/06
05/16
05/26
06/05
06/15
06/25
TSP Concentration (mg/m3)
Wind speed (m/s)
Date

# APPENDIX C TEOM STATION 24-HOUR AVERAGE DATA

## Table 20: 24-Hour Averaged Tsay Keh Dene TEOM Monitoring Station Data

| Date | pm10 | pm10_Max | pm25 | pm25_Max | ws_Avg | ws_Max | WinDir | AirTemp | RH | Pressure | Rainfall |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 01-Jan-15 | 2.170043 | 4.407 | 2.045754 | 4.224 | 0.6788889 | 3.43 | 230.2644 | -11.21354 | 81.13958 | 101.7965 | 0 |
| 02-Jan-15 | 5.41891 | 10.06 | 3.622373 | 5.965 | 3.075819 | 8.62 | 329.2215 | -12.49382 | 74.95576 | 101.7965 | 0.1 |
| 03-Jan-15 | 2.315268 | 6.667 | 2.258676 | 6.467 | 1.752618 | 9.31 | 297.3227 | -26.03417 | 61.37799 | 103.5757 | 0 |
| 04-Jan-15 | 2.900381 | 6.55 | 2.743667 | 5.938 | 1.189451 | 4.802 | 258.6686 | -31.91576 | 58.71382 | 102.9646 | 0 |
| 05-Jan-15 | 2.797121 | 4.645 | 2.595864 | 4.321 | 1.498035 | 5.194 | 299.9158 | -28.35194 | 59.91576 | 102.6903 | 0 |
| 06-Jan-15 | 2.780758 | 6.169 | 2.246848 | 5.989 | 0.7845833 | 4.704 | 181.9586 | -18.20583 | 72.42361 | 103.3264 | 0 |
| 07-Jan-15 | 3.525016 | 7.715 | 3.291175 | 7.515 | 1.514903 | 9.02 | 235.2205 | -11.41653 | 80.25868 | 102.8833 | 0 |
| 08-Jan-15 | 2.919939 | 10.96 | 2.675061 | 10.04 | 1.396451 | 7.742 | 302.8959 | -14.37319 | 72.31174 | 103.6271 | 0 |
| 09-Jan-15 | 1.828468 | 5.204 | 1.845364 | 4.784 | 0.5487569 | 2.94 | 187.26 | -13.44264 | 75.06722 | 102.2007 | 0 |
| 10-Jan-15 | 3.038683 | 9.24 | 2.901095 | 8.7 | 0.5866806 | 2.744 | 217.542 | -9.284396 | 79.76028 | 101.7444 | 0 |
| 11-Jan-15 | 1.58771 | 10.55 | 1.511464 | 10.22 | 0.4425972 | 2.94 | 123.8958 | -6.74316 | 83.9375 | 102.0771 | 0 |
| 12-Jan-15 | 3.119778 | 12.45 | 2.770639 | 11.92 | 1.990257 | 9.31 | 120.8036 | -4.890083 | 87.27854 | 102.2701 | 0 |
| 13-Jan-15 | 1.234826 | 3.016 | 0.9057217 | 2.808 | 4.186451 | 11.27 | 160.3958 | -2.301257 | 90.83056 | 101.9903 | 0 |
| 14-Jan-15 | 3.036816 | 11.38 | 2.625737 | 9.88 | 2.765132 | 10.09 | 168.12 | -1.899903 | 90.925 | 101.6542 | 0 |
| 15-Jan-15 | 0.2412128 | 1.069 | 0.2111667 | 1.065 | 4.119035 | 14.31 | 157.7969 | -0.7963958 | 88.23556 | 100.5146 | 0 |
| 16-Jan-15 | 1.107193 | 3.182 | 0.9830789 | 3.098 | 1.777389 | 8.43 | 166.7078 | -1.687243 | 84.07236 | 100.316 | 0 |
| 17-Jan-15 | 0.6310641 | 1.497 | 0.5205455 | 1.29 | 2.849993 | 12.45 | 158.516 | -1.566153 | 88.075 | 100.625 | 0 |
| 18-Jan-15 | 2.965587 | 10.57 | 2.847075 | 10.03 | 0.6405903 | 7.154 | 152.8825 | -1.541042 | 90.12528 | 100.1125 | 0 |
| 19-Jan-15 | 1.320563 | 3.206 | 1.129306 | 2.979 | 1.6935 | 5.978 | 166.08 | -1.656944 | 89.73403 | 101.3347 | 0 |
| 20-Jan-15 | 2.529134 | 10.68 | 2.836685 | 10.2 | 3.227944 | 13.92 | 147.8733 | -3.878674 | 90.17569 | 102.0208 | 0 |
| 21-Jan-15 | 0.9800732 | 2.695 | 0.4611887 | 1.105 | 7.188639 | 19.01 | 156.4133 | 0.7542153 | 87.60486 | 100.6361 | 5.7 |
| 22-Jan-15 | 1.755176 | 3.024 | 1.593049 | 2.818 | 3.749868 | 15.29 | 157.7544 | 1.871757 | 87.19375 | 100.8319 | 7.7 |
| 23-Jan-15 | 2.382326 | 4.697 | 2.121395 | 4.415 | 4.365721 | 14.01 | 155.881 | 1.665163 | 87.83953 | 101.0953 | 0 |
| 24-Jan-15 | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| 25-Jan-15 | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| 26-Jan-15 | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| 27-Jan-15 | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| 28-Jan-15 | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| 29-Jan-15 | 1.793843 | 4.765 | 1.523584 | 4.506 | 1.587672 | 7.546 | 164.5685 | -3.536784 | 88.104 | 102.2456 | 0 |
| 30-Jan-15 | 1.306127 | 3.978 | 1.285333 | 3.861 | 1.356639 | 5.782 | 285.8881 | -3.362333 | 83.62924 | 102.491 | 0 |
| 31-Jan-15 | 2.648769 | 10.45 | 2.446769 | 8.64 | 1.324229 | 6.272 | 298.5388 | -9.237951 | 74.27535 | 102.7361 | 0.1 |
| 01-Feb-15 | 3.390405 | 9.44 | 3.063225 | 8.78 | 1.457931 | 8.33 | 280.925 | -15.08188 | 71.63681 | 102.0181 | 0 |
| 02-Feb-15 | 2.409134 | 8.47 | 1.545083 | 8.15 | 3.076653 | 9.51 | 321.6153 | -17.66222 | 60.75028 | 101.8646 | 0 |
| 03-Feb-15 | 13.69472 | 85 | 11.38589 | 76.25 | 0.7600208 | 3.92 | 232.6989 | -23.26153 | 61.04389 | 102.1556 | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| **04-Feb-15** | 1.585393 | 7.918 | 1.420768 | 7.538 | 1.018972 | 4.214 | 271.5949 | -14.82917 | 66.62521 | 101.509 | 0 |
| **05-Feb-15** | 3.40556 | 9.36 | 0.3127027 | 1.001 | 2.378764 | 8.92 | 291.4067 | -13.02535 | 73.42604 | 100.6021 | 0 |
| **06-Feb-15** | 1.959361 | 7.711 | 1.099614 | 2.314 | 0.5170278 | 4.998 | 195.361 | -17.16035 | 72.64278 | 99.49653 | 0 |
| **07-Feb-15** | 3.616803 | 7.626 | 2.795087 | 5.217 | 1.57766 | 5.88 | 312.3874 | -19.96285 | 66.85674 | 99.82014 | 0 |
| **08-Feb-15** | 7.676252 | 20.62 | 6.83929 | 17.63 | 0.6151736 | 4.41 | 191.8156 | -19.90715 | 66.13375 | 101.3778 | 0 |
| **09-Feb-15** | 2.520717 | 14.7 | 2.293492 | 13.84 | 1.70491 | 6.37 | 314.2563 | -16.24097 | 69.66215 | 101.4521 | 0 |
| **10-Feb-15** | 10.11116 | 46.87 | 8.79115 | 42.61 | 0.4616875 | 2.94 | 183.3052 | -19.03444 | 69.20653 | 102.4528 | 0 |
| **11-Feb-15** | 1.896659 | 5.966 | 1.714198 | 3.613 | 0.8450278 | 5.488 | 182.4293 | -10.88034 | 78.81569 | 101.8944 | 0 |
| **12-Feb-15** | 4.411493 | 13.81 | 3.747528 | 11.91 | 0.6204375 | 2.94 | 210.3023 | -5.070903 | 87.46076 | 101.6292 | 0 |
| **13-Feb-15** | 2.770044 | 9.66 | 2.366933 | 9.2 | 1.100854 | 6.566 | 172.9754 | 0.5600486 | 94.70972 | 101.4465 | 17.5 |
| **14-Feb-15** | 1.93918 | 10.42 | 1.757744 | 10.72 | 1.323611 | 5.978 | 198.603 | -1.406806 | 88.39174 | 102.0146 | 2 |
| **15-Feb-15** | 5.2838 | 19.43 | 4.617048 | 18.77 | 0.5037917 | 2.842 | 188.2598 | -3.765056 | 80.65153 | 102.7472 | 2.7 |
| **16-Feb-15** | 8.303348 | 18.52 | 7.961753 | 19.8 | 0.4928472 | 1.666 | 189.9688 | -6.879396 | 79.11736 | 103.0764 | 0.1 |
| **17-Feb-15** | 6.114351 | 15.68 | 5.783991 | 15.15 | 0.6322778 | 4.312 | 187.3296 | -3.857056 | 84.00313 | 102.184 | 0.4 |
| **18-Feb-15** | 4.869068 | 15.77 | 4.657379 | 14.93 | 0.4938333 | 3.43 | 163.2634 | -4.954201 | 84.96049 | 101.5021 | 0 |
| **19-Feb-15** | 6.375744 | 12.13 | 5.732802 | 11.06 | 0.3729028 | 2.842 | 164.1745 | -3.506292 | 85.42889 | 101.5299 | 0.9 |
| **20-Feb-15** | 5.134904 | 18.03 | 4.631664 | 17.84 | 1.54091 | 10.68 | 287.3412 | -1.961521 | 77.08722 | 102.3299 | 0.2 |
| **21-Feb-15** | 5.204324 | 19.65 | 4.923565 | 20.04 | 0.6858889 | 3.234 | 234.7981 | -5.893382 | 74.14549 | 103.1507 | 0 |
| **22-Feb-15** | 3.515664 | 14.63 | 3.574345 | 14.14 | 0.6957917 | 4.998 | 191.5169 | -3.514049 | 74.68354 | 102.7215 | 0 |
| **23-Feb-15** | 6.124383 | 33.34 | 5.4045 | 29.79 | 1.395344 | 7.742 | 202.1989 | -2.556405 | 74.53756 | 102.258 | 0.1 |
| **24-Feb-15** | 6.386016 | 17.6 | 6.228883 | 15.09 | 1.122146 | 8.53 | 258.507 | -1.877292 | 68.86785 | 102.0132 | 0 |
| **25-Feb-15** | 6.521244 | 34.04 | 5.857917 | 34.93 | 0.6738889 | 2.548 | 235.6921 | -7.525951 | 72.39986 | 102.4215 | 0 |
| **26-Feb-15** | 2.249792 | 7.822 | 1.878429 | 7.481 | 2.628285 | 11.56 | 272.6523 | -2.844417 | 65.27917 | 102.1486 | 0 |
| **27-Feb-15** | 3.207068 | 13.56 | 2.748733 | 12.25 | 2.299354 | 10.78 | 287.733 | -5.168979 | 56.94868 | 102.3854 | 0 |
| **28-Feb-15** | 7.490561 | 24.72 | 6.264439 | 24.26 | 0.7538194 | 3.234 | 211.7165 | -10.01667 | 69.41917 | 102.4007 | 0 |
| **01-Mar-15** | 4.724523 | 12.04 | 3.836773 | 11.44 | 2.090611 | 12.64 | 298.7294 | -7.448813 | 61.56597 | 101.8576 | 0 |
| **02-Mar-15** | 2.482293 | 10.57 | 2.168422 | 7.807 | 2.288264 | 7.448 | 235.5289 | -7.279958 | 49.82625 | 102.6451 | 0 |
| **03-Mar-15** | 15.9019 | 153 | 14.08112 | 129.2 | 0.6486319 | 3.136 | 187.2522 | -15.14287 | 61.97208 | 102.4257 | 0 |
| **04-Mar-15** | 8.893558 | 51.8 | 6.234108 | 43.91 | 0.8596667 | 5.978 | 220.7686 | -12.43888 | 62.46542 | 101.9125 | 0 |
| **05-Mar-15** | 7.51391 | 15.14 | 4.165479 | 8.52 | 1.212007 | 7.938 | 157.1515 | -4.306174 | 74.78146 | 101.4507 | 0.1 |
| **06-Mar-15** | 4.406 | 8.72 | 3.592053 | 8.33 | 1.144153 | 7.644 | 261.5722 | -0.2387917 | 71.03563 | 102.0896 | 0 |
| **07-Mar-15** | 5.216756 | 17.88 | 5.140731 | 18.52 | 1.003208 | 5.586 | 198.202 | -4.630236 | 70.79549 | 102.1104 | 0 |
| **08-Mar-15** | 5.77325 | 8.04 | 5.3435 | 7.645 | 2.017618 | 8.92 | 166.0737 | 3.355438 | 64.53139 | 100.9299 | 0 |
| **09-Mar-15** | 3.084361 | 9.77 | 2.981606 | 8.73 | 1.641111 | 9.7 | 258.0885 | 1.236924 | 53.92403 | 100.7069 | 0 |
| **10-Mar-15** | 4.205077 | 19.59 | 3.81719 | 16.9 | 0.8672917 | 4.704 | 231.3457 | -5.668431 | 62.52424 | 101.0521 | 0 |
| **11-Mar-15** | 2.744489 | 6.473 | 1.476152 | 3.768 | 1.453104 | 5.39 | 319.958 | -4.70059 | 78.8646 | 100.5771 | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 7 | | 5 | | |
| **12-Mar-15** | 1.599702 | 3.479 | 1.31827 | 2.699 | 2.708965 | 12.15 | 168.3123 | 1.924313 | 82.13493 | 100.8576 | 3.7 |
| **13-Mar-15** | 0.8731077 | 1.96 | 0.087 | 0.087 | 4.416056 | 15.09 | 146.4536 | 3.756243 | 70.84049 | 100.5306 | 0 |
| **14-Mar-15** | 2.731529 | 6.06 | 2.792692 | 5.59 | 3.192847 | 13.23 | 215.0398 | 2.009444 | 75.11653 | 99.47917 | 3.8 |
| **15-Mar-15** | 6.806561 | 39.01 | 6.988108 | 37.21 | 1.257028 | 9.02 | 251.8697 | -2.48634 | 52.67861 | 101.3764 | 0 |
| **16-Mar-15** | 5.798 | 19.25 | 5.244696 | 15.94 | 1.057118 | 6.076 | 253.9481 | -6.000861 | 65.66764 | 102.5375 | 0 |
| **17-Mar-15** | 7.918392 | 33.5 | 7.7259 | 30.04 | 0.9449444 | 4.116 | 261.5654 | -3.833333 | 62.91222 | 101.8646 | 0 |
| **18-Mar-15** | 9.7176 | 79.84 | 9.051632 | 70.56 | 1.191188 | 5.88 | 205.0929 | -1.98691 | 66.12965 | 101.6167 | 0 |
| **19-Mar-15** | 3.465621 | 13.79 | 2.918189 | 13.34 | 0.7772292 | 4.214 | 158.4859 | 1.928118 | 83.39979 | 101.2188 | 0.1 |
| **20-Mar-15** | 2.23452 | 5.312 | 1.788058 | 4.705 | 0.9101111 | 4.312 | 257.7034 | 1.507007 | 85.10542 | 101.1285 | 1.1 |
| **21-Mar-15** | 2.307198 | 8 | 2.075718 | 7.598 | 1.145861 | 5.096 | 214.8996 | 0.7403681 | 73.81889 | 101.3681 | 1.6 |
| **22-Mar-15** | 3.43391 | 13.94 | 3.183465 | 13.08 | 1.343576 | 6.174 | 175.9523 | -0.6334306 | 71.75229 | 101.5208 | 0 |
| **23-Mar-15** | 6.390476 | 36.79 | 5.435542 | 31.49 | 0.6345208 | 3.136 | 178.9291 | -0.2438542 | 72.3475 | 101.1236 | 0 |
| **24-Mar-15** | 4.577978 | 13.12 | 3.826196 | 11.37 | 0.8934931 | 5.488 | 175.2468 | -0.9002986 | 84.92757 | 101.3153 | 0.1 |
| **25-Mar-15** | 2.776508 | 7.357 | 2.054294 | 6.552 | 1.262924 | 6.566 | 197.7544 | -1.475514 | 81.31799 | 101.4125 | 0.1 |
| **26-Mar-15** | 2.744333 | 11.92 | 2.474389 | 11.16 | 1.084319 | 7.154 | 154.3545 | 1.874028 | 93.93028 | 101.2625 | 3.5 |
| **27-Mar-15** | 3.059681 | 12.18 | 2.588803 | 8.33 | 1.421097 | 5.88 | 167.6309 | 2.152181 | 86.71083 | 100.8826 | 0.1 |
| **28-Mar-15** | 2.331961 | 6.042 | 2.478541 | 8.34 | 1.528583 | 9.6 | 208.4087 | 1.031271 | 73.50021 | 100.9611 | 1.1 |
| **29-Mar-15** | 0.8433053 | 3.024 | 0.6177664 | 2.123 | 1.87734 | 12.25 | 166.8567 | 3.287458 | 80.54326 | 100.8882 | 0.5 |
| **30-Mar-15** | 1.026906 | 2.48 | 0.5746333 | 1.96 | 1.279597 | 7.154 | 7.863077 | 0.7169514 | 81.65861 | 100.9313 | 0 |
| **31-Mar-15** | 2.701848 | 11.82 | 2.315138 | 11.33 | 0.7408819 | 4.9 | 193.7271 | 2.817681 | 79.30257 | 100.5181 | 1.4 |
| **01-Apr-15** | 3.100324 | 7.769 | 2.919098 | 7.049 | 0.8912986 | 7.154 | 176.9135 | 3.57784 | 59.69174 | 101.441 | 0 |
| **02-Apr-15** | 4.707822 | 20.14 | 3.988478 | 15.94 | 1.113847 | 5.194 | 221.0699 | -0.4337083 | 69.62111 | 101.8764 | 0 |
| **03-Apr-15** | 7.779212 | 35.76 | 6.194439 | 31.54 | 0.9983681 | 6.174 | 214.3415 | -0.6102986 | 74.40028 | 101.6653 | 0 |
| **04-Apr-15** | 3.691875 | 14.59 | 3.41973 | 13.13 | 1.177583 | 6.37 | 173.7026 | 3.101646 | 66.02042 | 101.5187 | 0 |
| **05-Apr-15** | 2.753097 | 6.828 | 2.037243 | 3.798 | 1.126104 | 5.684 | 176.6008 | 1.713597 | 64.4334 | 101.2694 | 0 |
| **06-Apr-15** | 7.946351 | 39.71 | 6.195583 | 35.1 | 1.002477 | 5.586 | 204.2923 | -0.2730682 | 66.05106 | 100.9712 | 0 |
| **07-Apr-15** | 8.621644 | 31.38 | 6.139851 | 27.53 | 1.065389 | 5.782 | 221.248 | -0.09980556 | 65.14278 | 100.9583 | 0 |
| **08-Apr-15** | 7.90634 | 33.96 | 3.695119 | 24.45 | 1.337354 | 6.566 | 216.4007 | 1.090479 | 65.08917 | 101.2861 | 0 |
| **09-Apr-15** | 12.69388 | 50.84 | 4.285053 | 45.94 | 1.731544 | 8.72 | 177.6101 | 1.462792 | 66.32616 | 100.9872 | 0 |
| **10-Apr-15** | 8.659243 | 17.97 | 2.382007 | 5.188 | 2.601299 | 8.62 | 156.0304 | 2.812806 | 69.17632 | 99.80556 | 0 |
| **11-Apr-15** | 2.610917 | 11.17 | 1.802375 | 9.66 | 1.805646 | 9.31 | 215.4936 | 3.551778 | 51.37812 | 99.51597 | 0 |
| **12-Apr-15** | 7.958521 | 63.21 | 2.856405 | 13.92 | 1.749951 | 10.58 | 224.2746 | 2.322819 | 43.5009 | 100.5139 | 0 |
| **13-Apr-15** | 10.64558 | 45.9 | 3.078667 | 13.92 | 2.242465 | 10.98 | 206.6861 | 0.1897639 | 67.64549 | 100.4062 | 0.6 |
| **14-Apr-15** | 3.434514 | 21.89 | 2.271568 | 17.52 | 2.261937 | 10.68 | 194.7226 | 3.669729 | 60.60236 | 100.8132 | 0 |
| **15-Apr-15** | 18.11216 | 68.9 | 1.244579 | 4.076 | 3.389729 | 18.03 | 169.1791 | 2.810951 | 65.29354 | 101.484 | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| **16-Apr-15** | 4.529181 | 25.42 | 1.707441 | 8.88 | 1.616736 | 10.88 | 193.89 | 4.487681 | 55.35667 | 101.659 | 0 |
| **17-Apr-15** | 5.944725 | 24.41 | 3.490877 | 15.67 | 2.054056 | 10.39 | 285.0684 | 3.68666 | 61.5259 | 101.6799 | 1.9 |
| **18-Apr-15** | 7.495183 | 20.93 | 5.864843 | 12 | 1.090271 | 5.782 | 225.3013 | 2.3795 | 55.01194 | 102.6069 | 0 |
| **19-Apr-15** | 9.010222 | 33.57 | 4.784417 | 20.61 | 1.144847 | 5.684 | 208.0317 | 1.943056 | 62.89903 | 102.1306 | 0 |
| **20-Apr-15** | 10.35546 | 31.8 | 4.465104 | 17.05 | 0.9831944 | 6.762 | 144.7661 | 6.525736 | 64.00111 | 101.2396 | 0 |
| **21-Apr-15** | 5.248507 | 18.11 | 3.87775 | 16 | 1.197944 | 8.23 | 186.1978 | 6.037139 | 86.6659 | 100.7389 | 3.1 |
| **22-Apr-15** | 1.690009 | 3.763 | 0.8542024 | 2.206 | 2.885049 | 10.78 | 255.1324 | 6.035146 | 60.62583 | 100.9882 | 0.4 |
| **23-Apr-15** | 5.71084 | 23.66 | 4.387813 | 21.84 | 1.815528 | 7.546 | 273.0048 | 4.166958 | 79.99431 | 100.8146 | 3.8 |
| **24-Apr-15** | 4.598981 | 16.13 | 3.46301 | 15.38 | 2.964576 | 10.29 | 259.6904 | 4.904799 | 62.98694 | 100.9653 | 0.1 |
| **25-Apr-15** | 5.045625 | 14.27 | 3.045742 | 12.11 | 1.409264 | 6.174 | 185.531 | 3.814062 | 58.59681 | 101.4333 | 0 |
| **26-Apr-15** | 48.44715 | 397 | 5.539903 | 32.83 | 2.380465 | 10.09 | 170.7106 | 4.391306 | 65.09778 | 101.2819 | 0 |
| **27-Apr-15** | 31.96124 | 182.4 | 2.568644 | 11.97 | 2.868833 | 10.09 | 166.6867 | 5.222312 | 78.7609 | 101.225 | 0.1 |
| **28-Apr-15** | 25.37785 | 275.6 | 3.364722 | 14.41 | 2.713986 | 11.37 | 186.6042 | 7.788118 | 64.74333 | 100.441 | 1.6 |
| **29-Apr-15** | 5.388545 | 10.82 | 2.552907 | 4.788 | 1.644472 | 9.8 | 198.9541 | 6.08991 | 50.4916 | 100.8924 | 0 |
| **30-Apr-15** | 14.53727 | 161.9 | 1.58383 | 6.949 | 2.278694 | 10.09 | 173.6371 | 5.28216 | 60.29951 | 100.7264 | 0 |
| **01-May-15** | 0.7657143 | 1.521 | NaN | NaN | 1.269021 | 8.33 | 191.5609 | 5.033083 | 69.41889 | 100.7924 | 0.5 |
| **02-May-15** | NaN | NaN | NaN | NaN | 1.347811 | 8.04 | 233.9896 | 4.467273 | 58.79154 | 101.3776 | 0.5 |
| **03-May-15** | NaN | NaN | NaN | NaN | 2.122132 | 6.762 | 194.4888 | 6.156408 | 48.85105 | 101.4289 | 0 |
| **04-May-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **05-May-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **06-May-15** | NaN | NaN | NaN | NaN | 3.317833 | 7.448 | 170.3647 | 11.21944 | 37.625 | 121.1 | 0 |
| **07-May-15** | NaN | NaN | NaN | NaN | 2.215586 | 7.938 | 249.1379 | 15.94862 | 16.5069 | 101.8379 | 0 |
| **08-May-15** | NaN | NaN | NaN | NaN | 3.238615 | 7.84 | 161.104 | 15.34231 | 31.85962 | 101.7385 | 0 |
| **09-May-15** | 27.14 | 94.8 | 2.584667 | 7.012 | 2.007868 | 9.51 | 183.2076 | 16.86716 | 36.41118 | NaN | 0 |
| **10-May-15** | 33.79096 | 124.6 | 6.055435 | 32.33 | 1.485931 | 7.056 | 222.5603 | 12.88308 | 47.47715 | NaN | 0 |
| **11-May-15** | 43.98279 | 145.9 | 9.767167 | 35.79 | 1.380319 | 6.37 | 219.1366 | 13.26533 | 47.62222 | NaN | 0 |
| **12-May-15** | 34.3716 | 88.6 | 7.386708 | 16.88 | 1.554354 | 6.664 | 211.5646 | 13.10843 | 43.25951 | NaN | 0 |
| **13-May-15** | 37.77069 | 92.7 | 7.197104 | 26.03 | 1.482236 | 6.272 | 220.6906 | 12.93398 | 36.97532 | NaN | 0 |
| **14-May-15** | 62.42 | 186.1 | 15.14185 | 43.32 | 1.404993 | 5.88 | 209.6731 | 12.10175 | 41.91757 | NaN | 0 |
| **15-May-15** | 35.43799 | 186.1 | 12.99194 | 43.32 | 1.533569 | 13.82 | 200.7466 | 13.60455 | 41.95549 | NaN | 0 |
| **16-May-15** | 10.53002 | 33.1 | 3.658179 | 9 | 1.289326 | 4.998 | 205.0703 | 13.25847 | 55.3316 | NaN | 0.6 |
| **17-May-15** | 25.14113 | 89.5 | 4.79996 | 16.24 | 1.495396 | 6.076 | 201.7345 | 9.958819 | 47.05278 | NaN | 0 |
| **18-May-15** | 17.47478 | 58.8 | 3.491799 | 8.84 | 1.492437 | 7.448 | 194.3732 | 10.90066 | 47.08028 | NaN | 0 |
| **19-May-15** | 20.49316 | 58.8 | 5.230181 | 11.4 | 1.341785 | 7.644 | 206.6436 | 13.96844 | 53.86333 | NaN | 0.8 |
| **20-May-15** | 5.68459 | 17.85 | 2.464413 | 6.712 | 1.202597 | 7.35 | 212.9091 | 12.24736 | 68.78104 | NaN | 0.7 |
| **21-May-** | 7.528403 | 26.31 | 3.109384 | 8.44 | 1.892049 | 10.49 | 266.275 | 14.69759 | 54.4002 | NaN | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | | | | | | | 5 | | 1 | | |
| 22-May-15 | 14.66479 | 36.57 | 4.737146 | 10.63 | 2.971812 | 11.07 | 282.2497 | 17.76799 | 40.08375 | NaN | 0 |
| 23-May-15 | 30.58382 | 85.2 | 8.293458 | 11.52 | 1.330979 | 8.72 | 198.9603 | 17.48381 | 40.31778 | NaN | 0 |
| 24-May-15 | 33.3284 | 197.3 | 7.970319 | 16.17 | 1.447063 | 12.74 | 207.5809 | 17.19012 | 43.02681 | NaN | 0 |
| 25-May-15 | 36.49389 | 462.5 | 9.344764 | 34.11 | 1.278715 | 14.21 | 191.0696 | 15.67962 | 55.3475 | NaN | 0.1 |
| 26-May-15 | 17.77896 | 46.08 | 7.881903 | 11.91 | 1.235778 | 7.644 | 190.6362 | 14.38446 | 65.54417 | NaN | 0.6 |
| 27-May-15 | 11.96874 | 31.79 | 4.358355 | 8.47 | 1.667403 | 8.53 | 196.8408 | 16.48917 | 58.10736 | NaN | 0.1 |
| 28-May-15 | 2.303323 | 7.567 | 0.9520729 | 3.773 | 1.363194 | 5.684 | 288.7191 | 8.656938 | 77.37896 | NaN | 6.3 |
| 29-May-15 | 1.622318 | 7.145 | 0.8241429 | 4.878 | 0.9852917 | 3.92 | 203.7131 | 8.035764 | 82.72965 | NaN | 0.2 |
| 30-May-15 | 38.64127 | 512.8 | 2.904305 | 21.73 | 2.128035 | 12.35 | 224.672 | 9.331187 | 74.49 | NaN | 0 |
| 31-May-15 | 10.7072 | 48.42 | 2.796347 | 7.85 | 2.016194 | 11.56 | 212.7701 | 11.01541 | 70.76278 | NaN | 0 |
| 01-Jun-15 | 23.99957 | 84.3 | 4.123396 | 11.7 | 2.686806 | 10.09 | 202.2481 | 13.0539 | 63.29694 | NaN | 0 |
| 02-Jun-15 | 8.402319 | 16.96 | 2.871264 | 5.37 | 2.253917 | 8.62 | 172.6471 | 15.02569 | 55.93278 | NaN | 0 |
| 03-Jun-15 | 8.606326 | 44.67 | 3.098389 | 5.637 | 1.556007 | 10.98 | 159.8535 | 13.48271 | 79.93014 | NaN | 3.6 |
| 04-Jun-15 | 7.224965 | 34.77 | 1.853812 | 4.381 | 1.227757 | 6.37 | 201.3516 | 12.9408 | 69.03069 | NaN | 0 |
| 05-Jun-15 | 6.4095 | 19.47 | 1.613824 | 4.381 | 1.621271 | 8.62 | 211.3974 | 15.34353 | 55.63507 | NaN | 0 |
| 06-Jun-15 | 4.962232 | 27.91 | 1.617949 | 10.32 | 1.396451 | 8.53 | 201.3205 | 15.57611 | 44.22188 | NaN | 0 |
| 07-Jun-15 | 5.491812 | 27.91 | 2.25926 | 10.32 | 1.510451 | 9.41 | 163.0372 | 14.28396 | 68.66597 | NaN | 2.6 |
| 08-Jun-15 | 1.731542 | 4.188 | 0.77825 | 1.477 | 2.074174 | 11.56 | 244.6142 | 14.78799 | 52.71639 | NaN | 1.1 |
| 09-Jun-15 | 5.249114 | 43.21 | 1.905802 | 7.005 | 1.636389 | 5.684 | 210.5307 | 13.53276 | 44.97708 | NaN | 0 |
| 10-Jun-15 | 7.929896 | 43.21 | 2.564833 | 10.1 | 1.731611 | 8.62 | 230.2608 | 12.04042 | 53.87674 | NaN | 0 |
| 11-Jun-15 | 3.232205 | 7.939 | 1.510267 | 4.888 | 1.681354 | 11.66 | 233.0199 | 11.60313 | 56.98583 | NaN | 1.6 |
| 12-Jun-15 | 2.118899 | 8.03 | 0.9093704 | 2.401 | 2.888417 | 12.25 | 318.8186 | 11.49924 | 61.11799 | NaN | 0.2 |
| 13-Jun-15 | 5.568722 | 20.06 | 1.737493 | 3.503 | 2.166146 | 8.43 | 267.1478 | 14.38562 | 58.55972 | NaN | 0.1 |
| 14-Jun-15 | 6.283797 | 30.5 | 1.4664 | 4.264 | 1.672875 | 6.958 | 176.2778 | 15.4261 | 50.61375 | NaN | 0 |
| 15-Jun-15 | 12.02185 | 34.85 | 2.487587 | 7.787 | 1.738333 | 9.41 | 204.911 | 13.23605 | 53.16 | NaN | 0 |
| 16-Jun-15 | 3.94921 | 15.84 | 1.698692 | 4.42 | 2.698417 | 12.54 | 272.233 | 14.48694 | 59.25542 | NaN | 1.6 |
| 17-Jun-15 | 2.509603 | 5.211 | 0.7162121 | 2.098 | 1.785139 | 8.53 | 215.3423 | 12.70775 | 65.82556 | NaN | 0 |
| 18-Jun-15 | 5.754618 | 18.98 | 1.532278 | 3.342 | 1.827931 | 6.762 | 188.172 | 14.66556 | 60.94757 | NaN | 0 |
| 19-Jun-15 | 3.741736 | 7.195 | 1.263222 | 3.221 | 1.907687 | 7.84 | 225.1663 | 13.22014 | 71.51757 | NaN | 0 |
| 20-Jun-15 | 5.983319 | 26.42 | 1.940579 | 5.275 | 1.715111 | 11.17 | 176.1495 | 14.37816 | 66.60937 | NaN | 0 |
| 21-Jun-15 | 4.345688 | 10.93 | 1.872493 | 5.194 | 1.755979 | 8.92 | 192.0964 | 13.5103 | 76.84389 | NaN | 3.9 |
| 22-Jun-15 | 4.514007 | 10 | 2.060201 | 5.309 | 1.435389 | 8.13 | 188.4717 | 15.05424 | 72.83201 | NaN | 0.3 |
| 23-Jun-15 | 6.974694 | 26.73 | 3.78109 | 9.23 | 1.238903 | 8.23 | 232.1505 | 16.01335 | 64.98215 | NaN | 0.2 |
| 24-Jun-15 | 10.37709 | 26.73 | 4.794403 | 9.23 | 1.567472 | 9.7 | 183.8938 | 15.7214 | 65.87931 | NaN | 0 |
| 25-Jun-15 | 4.777188 | 35 | 2.406 | 5.116 | 2.030167 | 9.11 | 166.8978 | 16.66639 | 74.98729 | NaN | 2.6 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **26-Jun-15** | 2.047211 | 8.96 | 0.9213333 | 4.423 | 1.407861 | 7.448 | 9.10251 | 19.25278 | 47.81701 | NaN | 0 |
| **27-Jun-15** | 5.820583 | 17.66 | 1.7921 | 4.295 | 1.389583 | 8.13 | 237.5336 | 17.04043 | 48.65944 | NaN | 0 |
| **28-Jun-15** | 13.15268 | 67.59 | 3.48925 | 8.16 | 1.337062 | 6.076 | 196.9264 | 17.31974 | 53.03076 | NaN | 0 |
| **29-Jun-15** | 13.75782 | 89 | 4.761231 | 21.95 | 1.419208 | 9.11 | 224.1441 | 19.56606 | 51.12257 | NaN | 0 |
| **30-Jun-15** | 7.115812 | 22.97 | 2.412975 | 6.826 | 1.414743 | 7.742 | 208.0368 | 18.16229 | 60.3784 | NaN | 0 |
| **01-Jul-15** | 15.81287 | 61.32 | 4.832439 | 19.69 | 1.652576 | 8.33 | 197.5293 | 17.89203 | 57.63451 | NaN | 0 |
| **02-Jul-15** | 9.487405 | 31.56 | 3.462957 | 6.524 | 2.060382 | 11.17 | 224.4702 | 21.32215 | 40.01131 | NaN | 0 |
| **03-Jul-15** | 1.788385 | 4.119 | 0.8098 | 2.15 | 1.922715 | 9.02 | 271.0935 | 16.31059 | 34.5175 | NaN | 0 |
| **04-Jul-15** | 1.795409 | 4.327 | 0.7860667 | 1.696 | 2.907799 | 9.51 | 329.5109 | 17.15982 | 45.385 | NaN | 0.1 |
| **05-Jul-15** | 2.545684 | 6.052 | 0.6050909 | 1.806 | 1.297528 | 6.958 | 201.7703 | 15.89586 | 54.98986 | NaN | 0 |
| **06-Jul-15** | 2.234069 | 7.855 | 0.7901 | 1.319 | 1.805889 | 9.02 | 264.8946 | 21.27764 | 41.3166 | NaN | 0 |
| **07-Jul-15** | 2.342146 | 8.45 | 1.651111 | 5.442 | 1.925313 | 8.04 | 174.4043 | 20.4775 | 56.28924 | NaN | 0 |
| **08-Jul-15** | 7.366153 | 47.85 | 2.166097 | 9.71 | 1.547924 | 8.43 | 244.1083 | 21.63014 | 48.02669 | NaN | 0 |
| **09-Jul-15** | 6.121714 | 33.87 | 4.3794 | 9.85 | 1.803556 | 9.21 | 205.069 | 23.80347 | 28.21826 | NaN | 0 |
| **10-Jul-15** | 9.784236 | 25.88 | 4.151227 | 12.98 | 1.504569 | 9.6 | 234.1195 | 18.45458 | 47.9034 | NaN | 0.4 |
| **11-Jul-15** | 10.2086 | 24.02 | 6.287792 | 15.86 | 1.890722 | 10.09 | 238.005 | 16.35789 | 58.96944 | NaN | 0 |
| **12-Jul-15** | 4.995181 | 10.92 | 3.852545 | 7.645 | 1.312549 | 8.72 | 155.5459 | 16.7575 | 78.93903 | NaN | 13.5 |
| **13-Jul-15** | 2.633462 | 4.852 | 1.162722 | 2.919 | 1.301951 | 8.82 | 208.1595 | 14.40783 | 80.14896 | NaN | 1.8 |
| **14-Jul-15** | 1.874083 | 5.95 | 0.7846383 | 2.986 | 1.097035 | 6.37 | 195.3716 | 16.2066 | 67.03069 | NaN | 0.1 |
| **15-Jul-15** | 2.46675 | 5.95 | 0.4627083 | 2.986 | 1.480972 | 7.35 | 256.0205 | 11.15954 | 82.55715 | NaN | 6.5 |
| **16-Jul-15** | 2.184362 | 5.633 | 0.931902 | 2.7 | 1.699042 | 7.742 | 287.8759 | 14.50153 | 65.15799 | NaN | 0.8 |
| **17-Jul-15** | 3.17541 | 11.07 | 1.223186 | 4.055 | 1.003458 | 5.096 | 248.2243 | 13.15794 | 66.17931 | NaN | 0 |
| **18-Jul-15** | 3.579982 | 11.07 | 1.449406 | 4.055 | 1.885097 | 12.74 | 245.9675 | 20.30847 | 53.25056 | NaN | 0.1 |
| **19-Jul-15** | 4.077275 | 12.54 | 2.200694 | 3.319 | 1.270993 | 6.468 | 227.6552 | 18.03913 | 46.29194 | NaN | 0 |
| **20-Jul-15** | 7.059951 | 18.87 | 3.242295 | 6.765 | 0.7413542 | 7.742 | 211.8252 | 13.19514 | 81.24861 | NaN | 13.9 |
| **21-Jul-15** | 1.502659 | 5.183 | 0.3906024 | 1.07 | 0.9633056 | 4.9 | 196.0714 | 12.82875 | 89.14736 | NaN | 12.2 |
| **22-Jul-15** | 1.59513 | 3.616 | 0.3746429 | 0.92 | 1.346465 | 6.664 | 223.8897 | 13.37014 | 82.95174 | NaN | 6.7 |
| **23-Jul-15** | 3.088833 | 4.593 | 0.7221053 | 1.76 | 1.348618 | 6.762 | 200.3706 | 13.50782 | 78.79028 | NaN | 0.5 |
| **24-Jul-15** | 2.716087 | 5.194 | 0.915619 | 1.813 | 1.244653 | 8.04 | 192.0968 | 13.15722 | 81.07924 | NaN | 14.6 |
| **25-Jul-15** | 2.4903 | 4.484 | 0.7557857 | 1.769 | 1.534514 | 7.546 | 212.5074 | 12.71773 | 70.22924 | NaN | 0 |
| **26-Jul-15** | 2.616292 | 5.809 | 1.313053 | 3.512 | 1.269472 | 5.782 | 200.4592 | 12.93047 | 70.80389 | NaN | 0 |
| **27-Jul-15** | 2.414757 | 4.683 | 0.7541176 | 2.057 | 1.453958 | 7.938 | 180.746 | 15.06972 | 69.19639 | NaN | 0.1 |
| **28-Jul-15** | 1.381214 | 4.39 | 0.591 | 1.607 | 1.632444 | 10.19 | 159.503 | 15.57201 | 64.31535 | NaN | 3.8 |
| **29-Jul-15** | 2.960806 | 6.413 | 1.240089 | 2.357 | 1.387597 | 9.31 | 178.8354 | 15.18118 | 53.88965 | NaN | 0 |
| **30-Jul-15** | 3.174271 | 6.406 | 0.8778333 | 2.203 | 1.508681 | 7.35 | 198.6807 | 13.60154 | 66.06611 | NaN | 0 |
| **31-Jul-15** | 3.037813 | 16.54 | 0.663361 | 1.809 | 1.722979 | 8.13 | 164.665 | 15.99118 | 70.2747 | NaN | 0.2 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | | | | 4 | | 2 | | |
| **01-Aug-15** | 3.071619 | 5.942 | 0.8819479 | 2.151 | 1.667604 | 9.02 | 236.7841 | 14.95653 | 70.01653 | NaN | 0 |
| **02-Aug-15** | 2.670159 | 5.985 | 1.062635 | 3.464 | 0.8502986 | 4.018 | 11.16262 | 11.62831 | 82.91167 | NaN | 2.9 |
| **03-Aug-15** | 2.974799 | 7.029 | 1.356278 | 3.546 | 2.379382 | 7.84 | 311.7914 | 11.27056 | 91.06944 | NaN | 15.4 |
| **04-Aug-15** | 9.824114 | 95.7 | 10.01989 | 84.3 | 1.574861 | 9.41 | 193.2181 | 14.40465 | 75.18396 | NaN | 14.6 |
| **05-Aug-15** | 4.275146 | 9.76 | 1.002344 | 2.229 | 1.548292 | 7.938 | 279.9716 | 15.64118 | 68.45653 | NaN | 0 |
| **06-Aug-15** | 5.994681 | 9.76 | 1.418451 | 3.369 | 1.803465 | 8.53 | 184.935 | 17.08632 | 70.60958 | NaN | 0 |
| **07-Aug-15** | 5.406646 | 11.01 | 1.845076 | 8.04 | 2.336326 | 8.72 | 168.3189 | 17.35563 | 74.00167 | NaN | 0 |
| **08-Aug-15** | 5.68972 | 11.82 | 1.453009 | 5.435 | 1.412292 | 5.88 | 170.5742 | 17.76969 | 68.43715 | NaN | 0.2 |
| **09-Aug-15** | 5.52816 | 16.02 | 1.590261 | 3.365 | 1.319965 | 8.43 | 196.2705 | 15.93813 | 81.78396 | NaN | 5.5 |
| **10-Aug-15** | 4.688413 | 9.36 | 0.9747157 | 2.629 | 1.899396 | 9.8 | 190.5984 | 17.46257 | 66.23028 | NaN | 0 |
| **11-Aug-15** | 12.24719 | 66.14 | 1.436983 | 2.629 | 1.191986 | 6.566 | 163.103 | 15.68132 | 67.31639 | NaN | 0.4 |
| **12-Aug-15** | 4.210361 | 6.429 | 0.678553 | 1.772 | 1.845125 | 7.448 | 157.8937 | 15.8516 | 77.70493 | NaN | 0.7 |
| **13-Aug-15** | 3.395222 | 11.66 | 1.163269 | 7.158 | 1.348194 | 9.7 | 201.0504 | 15.72882 | 63.72097 | NaN | 1.2 |
| **14-Aug-15** | 4.526049 | 12.29 | 0.9111204 | 3.176 | 2.207243 | 7.84 | 304.1845 | 13.19629 | 54.78201 | NaN | 0 |
| **15-Aug-15** | 6.492118 | 9.22 | 1.728091 | 2.85 | 1.304944 | 6.272 | 228.8825 | 12.91188 | 65.32201 | NaN | 0 |
| **16-Aug-15** | 8.932306 | 15.01 | 2.367451 | 4.91 | 1.261583 | 5.292 | 215.0114 | 12.69975 | 71.61514 | NaN | 0 |
| **17-Aug-15** | 14.13426 | 46.5 | 2.240217 | 4.233 | 1.070764 | 6.076 | 246.0739 | 14.72924 | 64.94889 | NaN | 0 |
| **18-Aug-15** | 17.7206 | 51.95 | 1.679117 | 2.945 | 1.733389 | 9.11 | 200.084 | 16.60417 | 64.65764 | NaN | 0 |
| **19-Aug-15** | 3.577916 | 12.99 | 0.8533267 | 2.969 | 1.271215 | 11.56 | 208.9572 | 15.32083 | 54.26167 | NaN | 0.6 |
| **20-Aug-15** | 3.876855 | 8.54 | 0.6243667 | 2.899 | 1.122854 | 5.488 | 246.343 | 9.789882 | 81.10028 | NaN | 2.2 |
| **21-Aug-15** | 3.090364 | 5.461 | 0.7181333 | 1.708 | 1.176535 | 6.076 | 170.8237 | 12.19627 | 70.70854 | NaN | 0.1 |
| **22-Aug-15** | 3.231125 | 8.23 | 0.4705 | 0.744 | 3.137833 | 13.33 | 180.2017 | 13.00868 | 72.60639 | NaN | 0.7 |
| **23-Aug-15** | 2.7436 | 14.44 | 1.05375 | 2.474 | 1.321056 | 8.72 | 175.2844 | 11.98059 | 71.04812 | NaN | 3.4 |
| **24-Aug-15** | 3.196542 | 6.83 | 0.5743571 | 1.937 | 1.020646 | 8.23 | 220.0775 | 10.47956 | 69.53743 | NaN | 0 |
| **25-Aug-15** | 4.415917 | 23.62 | 0.68775 | 1.643 | 1.34591 | 6.174 | 268.7858 | 11.93046 | 69.84076 | NaN | 0.2 |
| **26-Aug-15** | 10.2811 | 49.38 | 0.5796364 | 1.509 | 1.384021 | 6.272 | 226.5639 | 12.07567 | 69.40875 | NaN | 0 |
| **27-Aug-15** | 10.37487 | 54.4 | 0.3856774 | 0.712 | 1.283771 | 7.252 | 234.0069 | 11.82335 | 65.56257 | NaN | 0 |
| **28-Aug-15** | 4.088035 | 20.92 | 0.8598485 | 3.148 | 2.286354 | 12.54 | 166.0446 | 13.97639 | 73.45174 | NaN | 3.5 |
| **29-Aug-15** | 2.082921 | 6.866 | 0.4513559 | 1.641 | 1.520792 | 7.742 | 178.3619 | 12.82486 | 79.4066 | NaN | 4.4 |
| **30-Aug-15** | 2.436022 | 17.11 | 0.7235918 | 1.375 | 2.741111 | 14.01 | 154.0259 | 12.19035 | 75.20931 | NaN | 2.8 |
| **31-Aug-15** | 1.606768 | 3.319 | 0.6386591 | 1.693 | 1.709792 | 15.68 | 204.5721 | 9.659958 | 59.59514 | NaN | 0 |
| **01-Sep-15** | 2.476316 | 5.438 | 0.414 | 1.669 | 1.321486 | 6.272 | 218.4967 | 6.152861 | 70.29354 | NaN | 0 |
| **02-Sep-15** | 2.363333 | 8.1 | 1.347333 | 5.488 | 3.226174 | 12.54 | 284.4682 | 7.278896 | 71.85125 | NaN | 0 |
| **03-Sep-15** | 5.83125 | 30.74 | 1.207875 | 5.943 | 1.082049 | 6.174 | 240.1432 | 7.423931 | 72.67042 | NaN | 0 |
| **04-Sep-15** | 3.165792 | 9.01 | 0.5872857 | 1.171 | 1.63441 | 8.23 | 216.3599 | 7.320993 | 69.61132 | NaN | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| **05-Sep-15** | 4.181333 | 12.63 | 1.712 | 5.601 | 1.460715 | 7.448 | 225.6056 | 7.87984 | 69.67132 | NaN | 0 |
| **06-Sep-15** | 5.071333 | 13.23 | 1.565261 | 3.59 | 1.206729 | 6.37 | 235.5283 | 7.065528 | 76.20076 | NaN | 0 |
| **07-Sep-15** | 4.902958 | 16.02 | 1.368421 | 4.723 | 1.561736 | 8.33 | 220.7447 | 8.567993 | 76.92063 | NaN | 0 |
| **08-Sep-15** | 8.107542 | 43.66 | 1.287395 | 3.488 | 0.9262083 | 5.684 | 180.4783 | 10.84243 | 69.8966 | NaN | 0 |
| **09-Sep-15** | 8.036437 | 32.34 | 1.322944 | 3.634 | 1.700417 | 7.252 | 68.40014 | 11.13998 | 72.12403 | NaN | 0 |
| **10-Sep-15** | 13.16332 | 56.29 | 1.421118 | 4.203 | 1.351806 | 7.742 | 211.0113 | 11.92758 | 77.72937 | NaN | 0 |
| **11-Sep-15** | 5.442398 | 15.78 | 1.345752 | 2.482 | 1.817243 | 9.6 | 178.8648 | 15.68667 | 71.72965 | NaN | 0 |
| **12-Sep-15** | 2.387275 | 5.27 | 1.042465 | 2.152 | 1.555611 | 11.37 | 219.2584 | 13.90097 | 55.41458 | NaN | 0.8 |
| **13-Sep-15** | 2.447702 | 4.668 | 1.582733 | 2.972 | 1.812271 | 8.92 | 264.0917 | 9.626007 | 65.98882 | NaN | 3.1 |
| **14-Sep-15** | 1.439813 | 5.901 | 1.18553 | 4.772 | 0.9761319 | 4.508 | 75.67443 | 6.713729 | 77.515 | NaN | 0 |
| **15-Sep-15** | 3.660743 | 16.54 | 1.410658 | 4.772 | 1.041931 | 5.88 | 218.0212 | 6.103854 | 74.0359 | NaN | 0.1 |
| **16-Sep-15** | 4.977597 | 17.54 | 2.732174 | 8.8 | 1.297569 | 8.82 | 225.9934 | 6.365958 | 76.74583 | NaN | 0 |
| **17-Sep-15** | 6.279014 | 26.66 | 3.336638 | 13.94 | 1.814035 | 10.58 | 201.4417 | 7.931687 | 75.28764 | NaN | 0.2 |
| **18-Sep-15** | 1.623742 | 5.723 | 0.5640811 | 1.224 | 3.487708 | 14.21 | 162.0364 | 10.78007 | 72.16792 | NaN | 0.3 |
| **19-Sep-15** | 1.607 | 4.961 | 1.107675 | 3.218 | 2.215486 | 11.47 | 264.6982 | 8.091389 | 62.58361 | NaN | 0.6 |
| **20-Sep-15** | 9.213424 | 114.7 | 2.899008 | 20.67 | 1.404924 | 8.72 | 284.8717 | 2.905278 | 62.31083 | NaN | 0 |
| **21-Sep-15** | 14.97365 | 57.68 | 3.831567 | 23.53 | 1.733097 | 9.8 | 225.8777 | 3.26 | 67.61472 | NaN | 0 |
| **22-Sep-15** | 2.837659 | 14.3 | 0.8010092 | 1.394 | 1.97009 | 12.54 | 182.844 | 6.801111 | 77.38167 | NaN | 2.1 |
| **23-Sep-15** | 1.442758 | 3.352 | 0.8464248 | 2.704 | 1.638333 | 9.8 | 215.2137 | 6.063111 | 85.57201 | NaN | 6.9 |
| **24-Sep-15** | 1.16271 | 2.869 | 1.030056 | 1.663 | 1.349715 | 12.45 | 215.0515 | 4.133771 | 91.00611 | NaN | 4.8 |
| **25-Sep-15** | 2.409798 | 9.28 | 1.735615 | 6.626 | 1.076819 | 5.292 | 213.0645 | 6.319618 | 70.75792 | NaN | 0.1 |
| **26-Sep-15** | 0.5978426 | 1.9 | 0.6300541 | 0.965 | 1.27091 | 6.37 | 204.3187 | 7.069875 | 57.29271 | NaN | 0 |
| **27-Sep-15** | 1.827529 | 8.44 | 1.028109 | 2.658 | 2.024681 | 9.9 | 234.3113 | 7.122424 | 67.97007 | NaN | 0.1 |
| **28-Sep-15** | 5.108583 | 26.6 | 1.132428 | 2.374 | 2.01109 | 8.72 | 163.1907 | 10.52375 | 76.38743 | NaN | 0.5 |
| **29-Sep-15** | 5.150362 | 17.15 | 2.145675 | 6.968 | 1.494042 | 8.62 | 202.6931 | 8.4225 | 83.90819 | NaN | 0 |
| **30-Sep-15** | 5.325569 | 15.62 | 3.290754 | 13.89 | 1.188701 | 6.174 | 163.9738 | 12.90986 | 73.88271 | NaN | 0 |
| **01-Oct-15** | 2.856042 | 5.074 | 1.647225 | 3.793 | 2.304278 | 10.58 | 273.5562 | 8.363799 | 87.09889 | NaN | 4.3 |
| **02-Oct-15** | 1.906743 | 5.964 | 1.179442 | 4.735 | 3.476021 | 11.86 | 334.9671 | 4.880882 | 67.15514 | NaN | 0.1 |
| **03-Oct-15** | 6.077284 | 26.18 | 4.200859 | 20.09 | 0.9704167 | 4.214 | 240.9558 | 2.298299 | 71.29528 | NaN | 0 |
| **04-Oct-15** | 4.258675 | 14.37 | 3.400267 | 11.66 | 0.8792639 | 4.606 | 268.158 | 0.8133542 | 80.11458 | NaN | 0 |
| **05-Oct-15** | 3.924649 | 13.04 | 3.495056 | 10.75 | 0.9610486 | 5.488 | 215.2175 | 2.226201 | 72.95493 | NaN | 0.1 |
| **06-Oct-15** | 3.297146 | 12.97 | 2.822043 | 11.61 | 0.6623333 | 3.038 | 232.9894 | 1.980792 | 76.14639 | NaN | 0 |
| **07-Oct-15** | 5.693755 | 16 | 4.626246 | 12.53 | 1.146882 | 7.056 | 204.1655 | 5.778931 | 77.98181 | NaN | 0 |
| **08-Oct-15** | 6.409806 | 14.39 | 5.027604 | 12.53 | 2.114722 | 13.92 | 195.9824 | 8.743722 | 86.92139 | NaN | 1.6 |
| **09-Oct-15** | 1.779375 | 8.03 | 2.1085 | 5.586 | 3.124972 | 14.9 | 156.3085 | 10.9925 | 88.11576 | NaN | 12.2 |
| **10-Oct-15** | 2.242783 | 7.096 | 1.37888 | 5.151 | 1.366507 | 7.742 | 172.415 | 11.19017 | 73.8143 | NaN | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 8 | | 1 | | |
| **11-Oct-15** | 3.767137 | 8.97 | 2.710536 | 8.49 | 2.199514 | 15.48 | 160.9928 | 9.509542 | 71.7275 | NaN | 0.9 |
| **12-Oct-15** | 1.367575 | 8.97 | 0.9863119 | 8.49 | 2.007035 | 15.19 | 151.1357 | 8.222806 | 70.59931 | NaN | 0 |
| **13-Oct-15** | 1.292949 | 3.982 | 0.9971593 | 3.691 | 1.404667 | 7.84 | 163.6261 | 7.135771 | 66.37625 | NaN | 0 |
| **14-Oct-15** | 1.872856 | 7.517 | 1.551942 | 6.548 | 0.99125 | 5.39 | 233.0102 | 5.836194 | 54.73444 | NaN | 0 |
| **15-Oct-15** | 3.294621 | 12.16 | 2.726841 | 10.92 | 0.6531875 | 2.548 | 295.009 | -1.121306 | 88.91854 | NaN | 1.3 |
| **16-Oct-15** | 4.946475 | 10.81 | 4.912588 | 10.25 | 0.6088472 | 2.156 | 235.7605 | 2.559799 | 86.85257 | NaN | 0 |
| **17-Oct-15** | 6.443236 | 14.29 | 5.877486 | 13.56 | 1.132465 | 10.19 | 196.9534 | 4.492847 | 90.81458 | NaN | 1.8 |
| **18-Oct-15** | 4.953958 | 9.36 | 4.288667 | 8.64 | 1.394486 | 10.19 | 181.1806 | 5.28975 | 92.83903 | NaN | 2.9 |
| **19-Oct-15** | 3.129632 | 7.553 | 2.434712 | 5.834 | 0.7297639 | 4.606 | 244.8074 | 4.832708 | 90.22194 | NaN | 1 |
| **20-Oct-15** | 6.522358 | 16.48 | 6.004767 | 16.38 | 1.456507 | 11.76 | 201.3975 | 1.512618 | 89.5391 | NaN | 5 |
| **21-Oct-15** | 6.15372 | 20.6 | 5.965381 | 20.35 | 2.435493 | 14.5 | 153.9758 | 7.720056 | 79.30354 | NaN | 2.2 |
| **22-Oct-15** | 1.399556 | 2.944 | 1.180913 | 2.646 | 1.163715 | 5.978 | 157.8672 | 6.577118 | 76.49444 | NaN | 0 |
| **23-Oct-15** | 4.713722 | 11.07 | 4.081239 | 10.34 | 0.6598333 | 5.88 | 245.4289 | 3.625 | 82.50438 | NaN | 0 |
| **24-Oct-15** | 5.846865 | 19.11 | 5.564817 | 18.03 | 1.126451 | 7.35 | 248.837 | 0.6408819 | 79.28167 | NaN | 0.1 |
| **25-Oct-15** | 6.194424 | 19.11 | 6.018788 | 18.03 | 0.5584792 | 2.646 | 253.0983 | -1.465611 | 81.83465 | NaN | 0 |
| **26-Oct-15** | 3.72671 | 12.67 | 3.475739 | 12.17 | 2.526125 | 9.51 | 316.2317 | 0.8947222 | 75.72493 | NaN | 2.8 |
| **27-Oct-15** | 5.564823 | 21.94 | 4.787314 | 18.69 | 0.648875 | 6.566 | 232.682 | -2.519299 | 77.95882 | NaN | 0.1 |
| **28-Oct-15** | 17.12477 | 30.45 | 16.81032 | 29.99 | 0.6782083 | 9.51 | 177.282 | 0.8281667 | 79.53257 | NaN | 0.1 |
| **29-Oct-15** | 15.26683 | 30.45 | 15.09462 | 29.99 | 0.7151111 | 8.13 | 152.6365 | 2.389 | 86.53 | NaN | 2.4 |
| **30-Oct-15** | 4.747451 | 13.86 | 4.540187 | 13.12 | 1.233111 | 9.11 | 178.7092 | 4.935389 | 81.78382 | NaN | 0 |
| **31-Oct-15** | 6.527562 | 31.2 | 5.948236 | 29.05 | 0.7491111 | 4.312 | 261.2437 | 2.157924 | 86.78458 | NaN | 0.3 |
| **01-Nov-15** | 1.664182 | 11.68 | 1.563588 | 11.09 | 2.127313 | 8.53 | 320.7482 | -0.0173 | 89.70867 | 100.7384 | 3.9 |
| **02-Nov-15** | 0 | 0 | 0 | 0 | 2.418312 | 9.11 | 300.4207 | -3.224965 | 78.51792 | 101.0931 | 0 |
| **03-Nov-15** | NaN | NaN | NaN | NaN | 0.873625 | 7.056 | 220.3195 | -1.365715 | 77.85056 | 101.3972 | 0.5 |
| **04-Nov-15** | NaN | NaN | NaN | NaN | 1.014993 | 6.272 | 174.1015 | 2.283618 | 78.95944 | 100.8972 | 0 |
| **05-Nov-15** | NaN | NaN | NaN | NaN | 2.016556 | 7.742 | 316.2378 | -1.749437 | 74.50104 | 101.6701 | 0 |
| **06-Nov-15** | NaN | NaN | NaN | NaN | 2.710444 | 15.68 | 204.1448 | -0.2163333 | 86.685 | 100.8403 | 3 |
| **07-Nov-15** | NaN | NaN | NaN | NaN | 0.6914167 | 5.194 | 220.7062 | 0.7163403 | 82.40653 | 100.7021 | 0 |
| **08-Nov-15** | NaN | NaN | NaN | NaN | 0.6423194 | 3.332 | 233.0074 | -1.189625 | 80.15174 | 101.2417 | 0 |
| **09-Nov-15** | NaN | NaN | NaN | NaN | 1.083049 | 8.62 | 228.6014 | -5.555632 | 79.27201 | 101.441 | 0 |
| **10-Nov-15** | 4.590621 | 11.18 | 4.194212 | 10.49 | 5.041382 | 18.72 | 163.8511 | 1.212826 | 81.09979 | 100.0674 | 0.1 |
| **11-Nov-15** | 1.489184 | 8.16 | 1.561583 | 7.944 | 1.236389 | 6.664 | 156.1757 | -0.3744097 | 63.62924 | 100.5958 | 1.2 |
| **12-Nov-15** | 1.703202 | 5.471 | 1.119019 | 3.995 | 4.289965 | 18.82 | 177.6154 | -0.3514444 | 80.57299 | 99.68819 | 0 |
| **13-Nov-15** | 1.87377 | 6.293 | 1.728024 | 6.103 | 0.8917639 | 4.704 | 203.2612 | -0.8753056 | 75.03736 | 99.46042 | 0 |
| **14-Nov-15** | 3.619619 | 13.73 | 3.596775 | 13.35 | 0.3920903 | 2.156 | 201.4953 | -3.317076 | 77.99125 | 100.3625 | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| **15-Nov-15** | 3.416651 | 9.04 | 3.46505 | 8.48 | 0.4697917 | 2.548 | 234.3241 | -4.591188 | 77.95965 | 100.5854 | 0 |
| **16-Nov-15** | 4.155449 | 14.78 | 4.4148 | 14.06 | 3.016965 | 16.27 | 195.1543 | -4.052708 | 84.75958 | 99.83889 | 0 |
| **17-Nov-15** | 6.293286 | 31.85 | 6.041778 | 30.76 | 1.134431 | 5.782 | 272.5938 | -6.461556 | 82.38833 | 99.54931 | 0.1 |
| **18-Nov-15** | 4.983132 | 14.56 | 5.009398 | 14 | 0.7398403 | 3.43 | 275.078 | -12.29414 | 76.15653 | 101.1507 | 0 |
| **19-Nov-15** | 5.254641 | 21.16 | 4.960524 | 21.3 | 1.066563 | 6.37 | 291.4943 | -15.0848 | 75.01125 | 101.9569 | 0 |
| **20-Nov-15** | 5.44595 | 25.32 | 5.149368 | 23.7 | 1.142514 | 7.154 | 249.2887 | -11.95538 | 77.97187 | 102.5125 | 0 |
| **21-Nov-15** | 2.213307 | 10.84 | 2.277079 | 10.34 | 2.193924 | 10.58 | 175.4882 | 0.7593125 | 76.26472 | 101.1826 | 0.2 |
| **22-Nov-15** | 6.826083 | 26.28 | 6.295733 | 24.46 | 1.287208 | 7.448 | 276.1405 | -3.014194 | 64.17375 | 101.4583 | 0 |
| **23-Nov-15** | 2.344896 | 26.28 | 2.079932 | 24.46 | 3.550125 | 11.76 | 330.691 | -8.447396 | 64.54618 | 102.0097 | 0 |
| **24-Nov-15** | 2.825633 | 8.03 | 2.741667 | 7.405 | 1.36916 | 8.04 | 300.2998 | -16.95007 | 66.3909 | 102.9986 | 0 |
| **25-Nov-15** | 4.365992 | 17.29 | 3.899591 | 16.14 | 1.210007 | 3.528 | 312.5545 | -17.5425 | 72.07778 | 103.2514 | 0 |
| **26-Nov-15** | 1.459625 | 3.354 | 1.319299 | 3.202 | 1.134778 | 2.744 | 310.8043 | -12.48736 | 71.59083 | 103.3562 | 0 |
| **27-Nov-15** | 4.377799 | 9.26 | 4.182479 | 9.05 | 0.8030278 | 2.45 | 291.701 | -10.36201 | 70.71681 | 103.2354 | 0 |
| **28-Nov-15** | 6.822021 | 9.09 | 6.591833 | 8.32 | 0.669 | 2.058 | 281.7579 | -9.968403 | 71.09667 | 102.7826 | 0 |
| **29-Nov-15** | 5.436368 | 7.239 | 5.13934 | 6.757 | 0.7499653 | 2.744 | 287.3453 | -10.0366 | 71.72292 | 102.3382 | 0 |
| **30-Nov-15** | 5.910729 | 12.03 | 5.329389 | 11.08 | 0.7059444 | 2.45 | 271.9642 | -10.45861 | 75.0466 | 101.6792 | 0 |
| **01-Dec-15** | 6.431299 | 12.44 | 6.096924 | 11.99 | 1.487965 | 10.58 | 208.7342 | -6.031007 | 83.90681 | 101.0278 | 0 |
| **02-Dec-15** | 4.018879 | 7.24 | 3.92622 | 7.072 | 1.563222 | 8.72 | 201.9144 | -1.223667 | 85.90847 | 100.3778 | 0.2 |
| **03-Dec-15** | 1.352192 | 6.268 | 1.326858 | 6.241 | 1.990521 | 7.84 | 272.4823 | -0.62375 | 90.93194 | 99.625 | 0.1 |
| **04-Dec-15** | 2.421278 | 4.672 | 2.284715 | 4.534 | 1.736646 | 8.53 | 319.6342 | -3.140354 | 86.58819 | 99.88056 | 0 |
| **05-Dec-15** | 1.473929 | 5.178 | 1.371952 | 5.038 | 1.494806 | 4.018 | 331.8429 | -5.40975 | 84.56611 | 100.6222 | 0 |
| **06-Dec-15** | 1.095735 | 2.026 | 0.9746122 | 1.909 | 3.115882 | 12.74 | 170.3723 | 0.8559583 | 88.73056 | 99.80694 | 16.3 |
| **07-Dec-15** | 0.3022979 | 1.566 | 0.2545217 | 1.483 | 1.280354 | 9.51 | 164.7636 | 0.6230625 | 93.17153 | 99.67431 | 1.1 |
| **08-Dec-15** | 2.327571 | 5.434 | 2.279429 | 5.389 | 0.9865417 | 5.88 | 163.7876 | -1.255979 | 90.88264 | 99.45069 | 0 |
| **09-Dec-15** | 6.291888 | 24.6 | 6.095056 | 23.27 | 0.4599583 | 3.43 | 162.6952 | -3.816861 | 88.39632 | 99.59028 | 0 |
| **10-Dec-15** | 5.32024 | 16.07 | 5.21074 | 15.91 | 0.4738889 | 3.332 | 251.4477 | -6.312646 | 86.17153 | 99.86806 | 0 |
| **11-Dec-15** | 7.674826 | 32.03 | 7.642396 | 31.98 | 0.3674653 | 1.96 | 178.8044 | -7.201993 | 84.83451 | 100.3139 | 0 |
| **12-Dec-15** | 1.222392 | 4.245 | 1.314333 | 4.22 | 1.143826 | 7.154 | 252.1818 | -5.380451 | 84.91667 | 100.1326 | 0 |
| **13-Dec-15** | 2.325464 | 6.097 | 2.347492 | 5.97 | 2.144431 | 7.448 | 324.9084 | -9.319243 | 76.5766 | 100.4444 | 0 |
| **14-Dec-15** | 15.54605 | 47.17 | 15.17412 | 47 | 0.5347361 | 2.842 | 242.2251 | -16.89236 | 75.06965 | 101.525 | 0 |
| **15-Dec-15** | 4.918645 | 15.7 | 4.907306 | 15.69 | 0.7286667 | 3.822 | 265.504 | -12.01882 | 79.63528 | 101.6243 | 0 |
| **16-Dec-15** | 7.214312 | 53.99 | 7.062504 | 54.24 | 0.5411458 | 2.646 | 262.4692 | -14.0159 | 79.39375 | 102.0771 | 0 |
| **17-Dec-15** | 2.310814 | 9.61 | 2.353206 | 9.66 | 0.4882639 | 2.744 | 183.2341 | -11.285 | 78.69944 | 101.4118 | 0 |
| **18-Dec-15** | 3.393656 | 8.11 | 3.360865 | 8.01 | 0.6858819 | 5.88 | 233.7657 | -11.12625 | 79.46764 | 100.4361 | 0 |
| **19-Dec-15** | 6.037979 | 18.96 | 5.979472 | 18.67 | 0.69575 | 5.88 | 134.3835 | -9.983264 | 79.65153 | 100.2056 | 0 |
| **20-Dec-15** | 2.702007 | 5.348 | 2.699051 | 5.269 | 0.601437 | 2.646 | 250.878 | -9.063771 | 79.9832 | 99.47292 | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 5 | | 7 | | 6 | | |
| **21-Dec-15** | 2.393021 | 6.094 | 2.362979 | 6.03 | 0.6151597 | 2.94 | 275.9449 | -8.316611 | 81.79556 | 99.64792 | 0 |
| **22-Dec-15** | 1.633536 | 5.001 | 1.583754 | 4.957 | 0.5285694 | 2.352 | 261.0805 | -9.515104 | 78.36917 | 99.86319 | 0 |
| **23-Dec-15** | 2.080617 | 3.803 | 2.038675 | 3.729 | 0.6331667 | 2.45 | 264.3472 | -13.83708 | 75.51 | 100.3458 | 0 |
| **24-Dec-15** | 3.315507 | 11.21 | 3.220944 | 10.99 | 0.8309861 | 3.92 | 316.5278 | -21.78375 | 66.41889 | 101.2819 | 0 |
| **25-Dec-15** | 4.372029 | 19.63 | 4.260297 | 19.45 | 0.3794861 | 2.156 | 183.6608 | -21.00382 | 64.84688 | 102.3847 | 0 |
| **26-Dec-15** | 1.198929 | 4.077 | 1.304295 | 3.967 | 0.6692569 | 2.156 | 288.0062 | -16.22722 | 73.81917 | 102.2931 | 0 |
| **27-Dec-15** | 1.661614 | 4.042 | 1.610591 | 4.002 | 1.364479 | 4.41 | 325.1175 | -15.23299 | 75.64889 | 101.9444 | 0 |
| **28-Dec-15** | 3.722226 | 8.86 | 3.854268 | 8.86 | 0.5320833 | 3.43 | 244.9712 | -24.92361 | 65.52847 | 102.4347 | 0 |
| **29-Dec-15** | 2.484562 | 13.33 | 2.433007 | 13.19 | 0.8756806 | 2.842 | 303.4826 | -22.81319 | 70.36069 | 102.6292 | 0 |
| **30-Dec-15** | 3.533601 | 17.81 | 3.466906 | 17.61 | 0.3557708 | 2.156 | 177.45 | -24.90965 | 64.23812 | 103.3278 | 0 |
| **31-Dec-15** | 2.443567 | 7.59 | 2.352583 | 7.477 | 0.4494514 | 2.842 | 188.991 | -18.55701 | 72.82271 | 103.4812 | 0 |

### Table 21: 24-Hour Kwadacha TEOM Monitoring Station Data

| Date | pm10 | | pm25 | | ws_Avg | | WinDir | AirTemp | RH | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **04-Feb-15** | 9.462333 | 24.47 | 9.236333 | 24.06 | 1.116222 | 5.684 | 278.276 | -15.26174 | 67.6243 | 100.191 | 0 |
| **05-Feb-15** | 2.820517 | 6.799 | 2.1179 | 6.56 | 1.219611 | 6.762 | 223.822 | -17.41847 | 71.175 | 99.17639 | 0 |
| **06-Feb-15** | 3.413652 | 6.401 | 3.214739 | 6.073 | 1.352437 | 6.076 | 286.677 | -21.04222 | 64.2189 | 98.25 | 0 |
| **07-Feb-15** | 8.997319 | 40.3 | 8.744986 | 39.32 | 1.148049 | 5.194 | 316.881 | -22.6216 | 61.5519 | 99.89653 | 0 |
| **08-Feb-15** | 16.28517 | 98.9 | 14.38484 | 88.5 | 1.486208 | 5.684 | 300.286 | -20.2434 | 65.7565 | 100.4875 | 0.1 |
| **09-Feb-15** | 13.18775 | 33.85 | 12.01632 | 31.54 | 1.120931 | 4.508 | 312.488 | -17.5234 | 68.3902 | 100.9757 | 0 |
| **10-Feb-15** | 17.24865 | 57.99 | 17.09431 | 57.41 | 0.231576 | 2.548 | 175.146 | -15.64281 | 71.09792 | 101.3667 | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| **11-Feb-15** | 6.123275 | 16.59 | 6.014072 | 16.36 | 0.341451 | 2.94 | 202.377 | -8.275486 | 81.2726 | 100.6722 | 0 |
| **12-Feb-15** | 11.26217 | 24.9 | 11.04585 | 24.41 | 0.229520 | 2.254 | 193.134 | -3.238472 | 92.1930 | 100.6542 | 0 |
| **13-Feb-15** | 3.17658 | 9.71 | 3.067696 | 9.05 | 1.234083 | 8.92 | 125.000 | 1.277042 | 95.3236 | 100.5917 | 1.8 |
| **14-Feb-15** | 11.92376 | 31.43 | 11.78409 | 30.42 | 0.675583 | 3.822 | 155.7527 | -2.016132 | 88.6043 | 101.4313 | 5.5 |
| **15-Feb-15** | 12.13954 | 38.67 | 12.18908 | 38.09 | 0.7924444 | 4.116 | 276.615 | -3.422201 | 81.68924 | 102.1014 | 3.7 |
| **16-Feb-15** | 22.22801 | 59.74 | 22.19366 | 58.73 | 0.331069 | 4.41 | 159.088 | -2.781757 | 79.4873 | 101.6993 | 0 |
| **17-Feb-15** | 3.88427 | 16 | 3.606378 | 8.62 | 0.445201 | 5.586 | 164.357 | -3.759868 | 84.3921 | 100.9139 | 0 |
| **18-Feb-15** | NaN | NaN | NaN | NaN | 0.323708 | 2.646 | 197.798 | -3.122493 | 86.4359 | 100.3993 | 0 |
| **19-Feb-15** | NaN | NaN | NaN | NaN | 0.506 | 3.626 | 167.312 | -2.527167 | 83.8659 | 100.9361 | 0 |
| **20-Feb-15** | NaN | NaN | NaN | NaN | 0.9501458 | 4.802 | 290.710 | -3.735236 | 79.3963 | 101.9847 | 0.1 |
| **21-Feb-15** | NaN | NaN | NaN | NaN | 0.423555 | 2.548 | 230.799 | -4.291167 | 73.6457 | 101.9944 | 0 |
| **22-Feb-15** | NaN | NaN | NaN | NaN | 0.293298 | 4.9 | 178.468 | -2.931403 | 73.8056 | 101.6201 | 0.2 |
| **23-Feb-15** | NaN | NaN | NaN | NaN | 1.351021 | 8.92 | 163.131 | - | 72.0663 | 100.9514 | 0 |
| **24-Feb-15** | NaN | NaN | NaN | NaN | 1.129833 | 7.056 | 260.532 | -3.362368 | 67.0923 | 101.4007 | 0 |
| **25-Feb-15** | NaN | NaN | NaN | NaN | 0.688395 | 4.41 | 245.820 | -4.475882 | 69.9195 | 101.2438 | 0 |
| **26-Feb-15** | NaN | NaN | NaN | NaN | 2.552549 | 11.76 | 320.656 | -5.899486 | 64.5522 | 101.425 | 0 |
| **27-Feb-15** | NaN | NaN | NaN | NaN | 1.644944 | 6.076 | 312.420 | -6.977549 | 60.4797 | 101.5097 | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **28-Feb-15** | NaN | NaN | NaN | NaN | 0.460138 | 5.096 | 220.513 | -9.976076 | 66.4502 | 101.0722 | 0 |
| **01-Mar-15** | NaN | NaN | NaN | NaN | 1.61959 | 11.96 | 299.751 | -4.561806 | 48.5068 | 101.3306 | 0 |
| **02-Mar-15** | NaN | NaN | NaN | NaN | 0.484798 | 4.998 | 261.385 | -13.93341 | 55.7422 | 101.6618 | 0 |
| **03-Mar-15** | NaN | NaN | NaN | NaN | 0.48925 | 3.038 | 190.186 | -12.11596 | 55.4959 | 101.0875 | 0 |
| **04-Mar-15** | NaN | NaN | NaN | NaN | 0.635527 | 6.174 | 152.722 | -6.802993 | 56.32722 | 100.7292 | 0 |
| **05-Mar-15** | NaN | NaN | NaN | NaN | 0.73125 | 3.724 | 188.230 | -2.824792 | 81.1702 | 100.6014 | 0.4 |
| **06-Mar-15** | NaN | NaN | NaN | NaN | 0.729819 | 5.586 | 199.100 | -4.397792 | 67.7520 | 101.3069 | 1.5 |
| **07-Mar-15** | NaN | NaN | NaN | NaN | 1.152951 | 5.782 | 123.552 | 1.248799 | 60.8712 | 100.5104 | 0 |
| **08-Mar-15** | NaN | NaN | NaN | NaN | 0.897916 | 6.272 | 204.46 | 2.746139 | 64.8979 | 99.53819 | 0 |
| **09-Mar-15** | NaN | NaN | NaN | NaN | 1.041396 | 8.92 | 198.106 | - | 45.7332 | 100.0493 | 0 |
| **10-Mar-15** | NaN | NaN | NaN | NaN | 0.865041 | 6.37 | 271.396 | -5.549694 | 60.1409 | 99.83889 | 0 |
| **11-Mar-15** | NaN | NaN | NaN | NaN | 0.830923 | 5.292 | 284.694 | -7.366625 | 81.9451 | 99.58264 | 2 |
| **12-Mar-15** | NaN | NaN | NaN | NaN | 3.169715 | 13.52 | 136.347 | 4.710826 | 65.1273 | 99.91111 | 3 |
| **13-Mar-15** | NaN | NaN | NaN | NaN | 2.939174 | 14.7 | 153.789 | 5.88309 | 66.5422 | 98.52361 | 4 |
| **14-Mar-15** | NaN | NaN | NaN | NaN | 1.643347 | 11.37 | 222.3903 | -2.18284 | 61.3756 | 99.45486 | 0.1 |
| **15-Mar-15** | NaN | NaN | NaN | NaN | 0.823965 | 7.546 | 215.469 | -6.088167 | 57.6356 | 101.0979 | 0 |
| **16-Mar-15** | NaN | NaN | NaN | NaN | 0.871215 | 4.704 | 251.041 | -5.242069 | 60.8101 | 101.4042 | 0 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **17-Mar-15** | NaN | NaN | NaN | NaN | 0.42975 | 2.254 | 225.265 | -2.161285 | 58.5889 | 100.6729 | 0 |
| **18-Mar-15** | NaN | NaN | NaN | NaN | 0.659770 | 3.626 | 168.214 | 3.481062 | 60.8152 | 100.4236 | 0.3 |
| **19-Mar-15** | NaN | NaN | NaN | NaN | 0.521319 | 6.272 | 196.426 | 1.784076 | 78.1179 | 100.2403 | 0.4 |
| **20-Mar-15** | NaN | NaN | NaN | NaN | 0.129715 | 1.96 | 96.5483 | - | 84.4736 | 100.1715 | 4.1 |
| **21-Mar-15** | NaN | NaN | NaN | NaN | 0.561548 | 4.312 | 231.233 | -1.118535 | 75.2738 | 100.5979 | 1 |
| **22-Mar-15** | NaN | NaN | NaN | NaN | 0.752868 | 5.096 | 214.407 | -1.15309 | 71.9122 | 100.3056 | 0 |
| **23-Mar-15** | NaN | NaN | NaN | NaN | 0.660861 | 3.43 | 219.878 | 0.9204028 | 72.6832 | 100.1875 | 2.7 |
| **24-Mar-15** | NaN | NaN | NaN | NaN | 0.700909<br>7 | 4.018 | 229.895 | -1.358368 | 63.8291 | 100.4264 | 0 |
| **25-Mar-15** | NaN | NaN | NaN | NaN | 1.786194 | 6.664 | 130.530 | 2.773347 | 79.5347 | 100.2715 | 1.7 |
| **26-Mar-15** | NaN | NaN | NaN | NaN | 1.379493 | 8.53 | 147.723 | 3.29834 | 86.7636 | 100.1882 | 0 |
| **27-Mar-15** | NaN | NaN | NaN | NaN | 0.791979 | 6.076 | 214.552<br>4 | 1.685215 | 58.6801 | 99.81389 | 0 |
| **28-Mar-15** | NaN | NaN | NaN | NaN | 1.732694 | 10 | 134.408 | 4.399715 | 67.3918 | 99.85208 | 0.2 |
| **29-Mar-15** | NaN | NaN | NaN | NaN | 1.135444 | 7.154 | 160.441 | 2.923229 | 65.2352 | 100.0444 | 0 |
| **30-Mar-15** | NaN | NaN | NaN | NaN | 1.252118 | 7.644 | 181.153 | 2.396681 | 70.7420 | 99.52431 | 0 |
| **31-Mar-15** | NaN | NaN | NaN | NaN | 1.078572 | 8.04 | 237.487 | 3.663804 | 58.9339 | 99.93623 | 0 |
| **01-Apr-15** | NaN | NaN | NaN | NaN | 0.921041 | 5.978 | 213.857 | 1.704076 | 58.4511 | 100.7694 | 0 |
| **02-Apr-15** | 0 | 0 | 0 | 0 | 0.493111 | 3.626 | 221.150 | 0.2676806 | 59.4071 | 100.8014 | 0.4 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| **03-Apr-15** | 10.39063 | 28.42 | 6.563957 | 17.67 | 0.727402 | 5.684 | 119.243 | 3.190778 | 66.7492 | 100.6042 | 0.4 |
| **04-Apr-15** | 4.408194 | 15.05 | 4.164 | 14.44 | 0.592208 | 4.508 | 149.808 | 3.522625 | 56.3406 | 100.4729 | 0.1 |
| **05-Apr-15** | 5.737896 | 30.97 | 5.452972 | 29.79 | 0.755701 | 5.096 | 197.085 | 0.9107431 | 57.7994 | 100.1215 | NaN |
| **06-Apr-15** | 11.7949 | 41.26 | 10.15429 | 19.87 | 0.659638 | 4.802 | 157.246 | 1.281451 | 57.8225 | 99.91597 | 0 |
| **07-Apr-15** | 19.24901 | 65.4 | 13.08506 | 34.82 | 0.697534 | 6.468 | 205.6442 | 1.553847 | 59.2029 | 100.1104 | 0 |
| **08-Apr-15** | 16.92285 | 46.47 | 14.04785 | 43.41 | 0.8984167 | 7.154 | 179.496 | 3.980653 | 56.83924 | 100.2694 | 0 |
| **09-Apr-15** | 12.29583 | 67.32 | 1.637304 | 6.607 | 1.774743 | 9.41 | 138.127 | 6.485951 | 40.9382 | 99.39375 | 0 |
| **10-Apr-15** | 5.75769 | 16.67 | 1.239975 | 2.536 | 1.954549 | 9.9 | 180.531 | 3.928208 | 57.6584 | 98.39792 | 0.2 |
| **11-Apr-15** | 3.719765 | 19.38 | 1.968644 | 12.3 | 1.161125 | 9.41 | 187.798 | 1.747458 | 45.5477 | 98.93194 | 0 |
| **12-Apr-15** | 10.7891 | 33.59 | 4.544442 | 13.97 | 1.297535 | 9.21 | 210.402 | 0.3155139 | 49.1876 | 99.76944 | 0 |
| **13-Apr-15** | 6.343639 | 19.69 | 1.664054 | 6.497 | 2.245604 | 11.37 | 122.9097 | 3.292306 | 69.5381 | 99.16528 | 1.2 |
| **14-Apr-15** | 4.712111 | 12.74 | 1.868381 | 3.159 | 2.013021 | 11.47 | 182.599 | 2.466063 | 46.68354 | 100.3306 | 0 |
| **15-Apr-15** | 9.261819 | 27.32 | 3.72297 | 11.05 | 1.161264 | 10.58 | 157.064 | 2.283201 | 61.0761 | 100.441 | 0 |
| **16-Apr-15** | 5.623992 | 24.8 | 4.122175 | 21.61 | 1.04416 | 7.644 | 210.037 | 3.844639 | 55.0586 | 100.6285 | 0 |
| **17-Apr-15** | 6.767156 | 21.07 | 3.180509 | 13.02 | 1.248444 | 8.23 | 233.420 | 3.047535 | 54.5934 | 101.3375 | 0.1 |
| **18-Apr-15** | 21.38575 | 108.8 | 19.20967 | 87.6 | 0.905451 | 5.782 | 219.738 | 3.191896 | 50.7750 | 101.5007 | 0 |
| **19-Apr-15** | 8.124892 | 25.45 | 8.6334 | 23.6 | 0.843826 | 5.586 | 184.964 | 6.709764 | 56.8640 | 100.6715 | 0 |
| **20-Apr-15** | 6.03929 | 23.27 | 3.35025 | 10.68 | 0.829375 | 5.292 | 172.866 | 10.04386 | 61.0350 | 99.90347 | 0 |
| **21-Apr-15** | 2.114674 | 4.186 | 1.456667 | 3.655 | 1.603875 | 8.33 | 270.868 | 6.043757 | 73.1311 | 99.95833 | 3.4 |
| **22-Apr-15** | 3.776742 | 11.01 | 3.964234 | 9.17 | 1.404222 | 9.8 | 254.684 | 6.08141 | 44.9092 | 99.97708 | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| **23-Apr-15** | 1.687536 | 3.912 | 1.032821 | 2.221 | 1.785882 | 8.72 | 303.917 | 2.760875 | 79.6552 | 99.94028 | 0.9 |
| **24-Apr-15** | 8.578762 | 19.99 | 7.390048 | 19.42 | 0.818229 | 5.488 | 158.075 | 3.882625 | 57.9432 | 100.3285 | 0 |
| **25-Apr-15** | 8.283855 | 41.06 | 5.659932 | 39.44 | 1.221201 | 7.644 | 190.049 | 4.547743 | 53.5816 | 100.3778 | 0 |
| **26-Apr-15** | 4.221174 | 14.74 | 1.160766 | 3.169 | 2.192326 | 10.09 | 130.574 | 6.620243 | 60.4827 | 100.1535 | 0 |
| **27-Apr-15** | 4.392289 | 15.15 | 1.882379 | 4.175 | 1.504132 | 9.9 | 143.8591 | 6.96959 | 79.4944 | 99.72639 | 2.5 |
| **28-Apr-15** | 5.511533 | 18.98 | 5.160825 | 18.37 | 1.468028 | 10.58 | 164.649 | 5.306778 | 60.83083 | 99.76319 | 0.1 |
| **29-Apr-15** | NaN | NaN | NaN | NaN | 1.338646 | 8.62 | 191.186 | 4.968083 | 51.605 | 99.71944 | 0 |
| **30-Apr-15** | NaN | NaN | NaN | NaN | 1.183563 | 8.92 | 171.261 | 5.132222 | 55.5723 | 99.64861 | 0 |
| **01-May-15** | NaN | NaN | NaN | NaN | 1.013993 | 8.04 | 207.489 | 4.012007 | 65.0009 | 100.1667 | 0.5 |
| **02-May-** | NaN | NaN | NaN | NaN | 1.323028 | 7.644 | 229.430 | 4.911319 | 47.43 | 100.5167 | 0 |
| **03-May-** | NaN | NaN | NaN | NaN | 1.205285 | 8.43 | 251.848 | 5.080965 | 64.4666 | 100.5201 | 1.5 |
| **04-May-15** | NaN | NaN | NaN | NaN | 1.072722 | 7.056 | 213.445 | 4.698951 | 53.4100 | 100.5049 | 0 |
| **05-May-** | 4.227824 | 35 | 0.3659 | 1.04 | 0.765020 | 6.272 | 203.728 | 4.123167 | 53.1081 | 100.9083 | 0 |
| **06-May-** | NaN | NaN | NaN | NaN | 1.374493 | 5.978 | 246.947 | 7.082097 | 42.2954 | 100.8208 | 0 |
| **07-May-** | NaN | NaN | 16 | 16 | 0.8765 | 6.958 | 216.269 | 8.678437 | 40.7143 | 100.9535 | 0 |
| **08-May-** | NaN | NaN | NaN | NaN | 0.9035 | 5.488 | 220.564 | 11.33094 | 46.2538 | 100.7486 | 0 |
| **09-May-** | 6.603 | 6.603 | NaN | NaN | 1.336907 | 5.782 | 267.865 | 14.16801 | 40.4003 | 100.7871 | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| **10-May-15** | NaN | NaN | NaN | NaN | 1.245 | 2.548 | NaN | 21.09 | 27.11 | 100.8 | 0 |
| **11-May-15** | 14.7345 | 28.35 | 1.781795 | 5.038 | 1.75074 | 7.742 | 162.053 | 24.8834 | 17.5502 | 100.266 | 0 |
| **12-May-15** | 18.31394 | 48.65 | 7.423381 | 27.22 | 1.430149 | 8.72 | 203.788 | 16.06709 | 30.2428 | 99.93719 | 0 |
| **13-May-15** | 5.604836 | 14.66 | 10.63887 | 25.17 | 1.535625 | 7.252 | 140.653 | 22.61304 | 12.1313 | 100.0357 | 0 |
| **14-May-15** | 7.317964 | 22 | 9.369345 | 56.29 | 1.447291 | 7.056 | 282.131 | 17.76279 | 26.4441 | 99.86 | 0 |
| **15-May-15** | 8.421154 | 11.09 | 15.31615 | 22.61 | 1.682393 | 9.02 | 202.505 | 21.3875 | 24.7878 | 101.45 | 0 |
| **16-May-15** | 0.457 | 0.457 | 0.609090 | 1.59 | 1.340646 | 5.88 | 174.243 | 17.07604 | 36.7070 | 119.3542 | 0 |
| **17-May-15** | 4.618467 | 15.02 | 3.374421 | 13.22 | 0.920057 | 6.468 | 203.445 | 11.49808 | 40.1874 | 101.123 | 0 |
| **18-May-15** | 5.467557 | 15.55 | 3.936015 | 19.37 | 1.042213 | 8.62 | 153.505 | 14.83063 | 42.2002 9 | 101.0191 | 0 |
| **19-May-15** | 2.484816 | 6.518 | 3.541053 | 8.97 | 1.333526 | 8.13 | 184.066 | 17.90974 | 43.9148 | 100.9289 | 0 |
| **20-May-** | 1.871471 | 11.79 | 1.402588 | 7.175 | 1.153304 | 4.312 | 282.968 | 19.26522 | 44.8295 | 101.5435 | 0 |
| **21-May-15** | 1.951714 | 3.975 | 1.235258 | 2.218 | 1.367892 | 6.762 | 273.948 | 18.98838 | 37.0670 | 121 | 0 |
| **22-May-** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **23-May-** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **24-May-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **25-May-** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **26-May-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **27-May-** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **28-May-** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| **29-May-** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **30-May-** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **31-May-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **01-Jun-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **02-Jun-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **03-Jun-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **04-Jun-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **05-Jun-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **06-Jun-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **07-Jun-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **08-Jun-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **09-Jun-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **10-Jun-15** | 0 | 0 | 0 | 0 | 1.11771 | 7.84 | 214.976 | 16.26226 | 38.2841 | 99.84032 | 0 |
| **11-Jun-15** | 0.664632 | 1.075 | 0.63438 | 1.318 | 1.420549 | 9.31 | 281.370 | 10.83061 | 60.8484 | 100.1486 | 0.3 |
| **12-Jun-15** | NaN | NaN | NaN | NaN | 1.594361 | 7.938 | 307.381 8 | 12.94208 | 56.9750 | 100.6819 | 0 |
| **13-Jun-15** | 0.794423 1 | 1.704 | 3.769984 | 13.56 | 0.884069 | 7.056 | 197.516 | 15.44319 | 44.7363 | 101.3535 | 0 |
| **14-Jun-15** | 0.515812 | 1.225 | 7.431965 | 25.26 | 0.836006 | 5.292 | 172.986 | 14.10627 | 46.2145 | 101.2875 | 0 |
| **15-Jun-15** | NaN | NaN | NaN | NaN | 1.22834 | 11.47 | 278.907 | 17.11319 | 46.7365 | 100.5153 | 0 |
| **16-Jun-15** | 0.484777 | 1.163 | 1.343737 | 3.017 | 0.881097 | 8.92 | 165.544 | 12.57167 | 70.6536 | 100.7472 | 1.6 |
| **17-Jun-15** | 0.44575 | 0.601 | 2.043235 | 3.725 | 1.070431 | 7.644 | 160.841 | 13.96225 | 61.4146 | 100.275 | 0.1 |
| **18-Jun-15** | NaN | NaN | NaN | NaN | 0.845569 | 7.252 | 271.242 | 13.34812 | 68.8609 | 100.209 | 2.2 |
| **19-Jun-15** | 0.543833 | 0.821 | 3.024619 | 4.42 | 0.953923 | 8.82 | 227.431 | 13.64647 | 62.1394 | 100.4271 | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| **20-Jun-15** | 0.392615 | 0.898 | 4.018353 | 5.78 | 0.9221528 | 13.03 | 233.690 | 14.81532 | 59.0427 | 100.4604 | 0.2 |
| **21-Jun-15** | 0.423764 | 0.707 | 3.55897 | 4.568 | 0.717562 | 6.566 | 178.21 | 14.9366 | 64.7122 | 100.4215 | 0 |
| **22-Jun-15** | 0.358235 | 0.767 | 1.875892 | 2.835 | 0.794138 | 6.762 | 169.391 | 15.38108 | 66.2424 | 100.5563 | 0.1 |
| **23-Jun-15** | 0.159666 | 0.179 | 3.2538 | 3.402 | 0.864173 | 5.782 | 177.793 | 17.19674 | 59.3897 | 100.4201 | 0 |
| **24-Jun-15** | NaN | NaN | NaN | NaN | 1.166611 | 9.7 | 123.838 | 19.73528 | 51.2270 | 100.3437 | 0 |
| **25-Jun-15** | NaN | NaN | NaN | NaN | 1.287806 | 8.04 | 136.802 | 16.12771 | 74.2811 | 100.5535 | 3.1 |
| **26-Jun-15** | 0.334695 | 0.591 | 1.756889 | 2.192 | 0.762590 | 6.664 | 174.809 | 16.56583 | 49.0063 | 100.7167 | 0 |
| **27-Jun-15** | 0.912933 | 1.828 | 6.261911 | 13.72 | 0.587687 | 6.468 | 171.892 | 15.58555 | 54.6241 | 100.8042 | 0 |
| **28-Jun-15** | 0.277 | 0.52 | 2.758875 | 2.854 | 0.600930 | 6.958 | 125.574 | 19.44153 | 54.1222 | 100.6951 | 0 |
| **29-Jun-15** | 12.061 | 24 | 33 | 33 | 1.344167 | 8.82 | 259.0956 | 18.74646 | 58.7073 | 100.6049 | 0 |
| **30-Jun-15** | 0.749806 | 1.148 | 4.211094 | 33 | 0.880298 | 6.076 | 257.926 | 18.63892 | 44.5830 | 100.7833 | 0 |
| **01-Jul-15** | NaN | NaN | NaN | NaN | 0.827388 | 5.488 | 132.6341 | 21.60174 | 44.0079 | 100.566 | 0 |
| **02-Jul-15** | NaN | NaN | NaN | NaN | 1.089118 | 8.23 | 255.994 | 19.27056 | 26.9834 | 100.4236 | 0 |
| **03-Jul-15** | 1.015125 | 1.705 | 3.211958 | 6.395 | 1.301486 | 9.41 | 290.953 | 15.6384 | 47.7183 | 100.7764 | 0.1 |
| **04-Jul-15** | 0.604731 | 2 | 16.50932 | 47.5 | 0.827263 | 8.33 | 221.766 | 14.89294 | 53.21951 | 101.2104 | 0 |
| **05-Jul-15** | 0.877 | 0.877 | 6.34 | 6.34 | 0.936763 | 5.096 | 244.814 | 19.20563 | 46.8772 | 100.7611 | 0 |
| **06-Jul-15** | 0.016 | 0.016 | 10.48 | 10.48 | 0.844131 | 6.86 | 203.068 | 21.0925 | 46.1957 | 100.75 | 0 |
| **07-Jul-15** | NaN | NaN | NaN | NaN | 0.956951 | 7.448 | 157.299 | 21.35576 | 52.0438 | 99.96042 | 0.2 |
| **08-Jul-15** | NaN | NaN | NaN | NaN | 1.140326 | 9.31 | 268.835 | 22.67347 | 35.8768 | 99.59931 | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| **09-Jul-15** | NaN | NaN | NaN | NaN | 0.951520 | 6.468 | 251.669 | 19.28549 | 43.11 | 99.62083 | 0 |
| **10-Jul-15** | NaN | NaN | NaN | NaN | 0.596118 | 6.37 | 153.417 | 17.07373 | 54.2734 | 99.66319 | 0 |
| **11-Jul-15** | NaN | NaN | NaN | NaN | 0.877159 | 8.72 | 173.793 | 18.42021 | 66.9092 | 99.72847 | 7.2 |
| **12-Jul-15** | NaN | NaN | NaN | NaN | 0.774305 | 5.292 | 212.357 | 14.51826 | 84.0405 | 100.1208 | 3.6 |
| **13-Jul-15** | NaN | NaN | NaN | NaN | 0.555152 | 4.704 | 179.456 | 14.63937 | 81.5327 | 100.2368 | 4.1 |
| **14-Jul-15** | NaN | NaN | NaN | NaN | 0.621951 | 5.292 | 159.827 | 13.24466 | 75.4994 | 100.0264 | 4.7 |
| **15-Jul-15** | NaN | NaN | NaN | NaN | 1.064646 | 7.938 | 267.592 | 11.26754 | 77.1636 | 100.2069 | 2 |
| **16-Jul-15** | NaN | NaN | NaN | NaN | 0.703437 | 9.31 | 241.794 | 12.49962 | 62.5945 | 100.9493 | 0 |
| **17-Jul-15** | NaN | NaN | NaN | NaN | 0.634770 | 9.21 | 153.163 | 16.92507 | 64.9752 | 100.6535 | 0.2 |
| **18-Jul-15** | NaN | NaN | NaN | NaN | 1.30459 | 13.43 | 292.295 | 16.77228 | 51.5963 | 100.4521 | 0.1 |
| **19-Jul-15** | NaN | NaN | NaN | NaN | 0.555736 | 5.586 | 147.857 | 18.47215 | 53.9181 | 100.2479 | 2.6 |
| **20-Jul-15** | NaN | NaN | NaN | NaN | 0.407881 | 5.782 | 227.076 | 11.95583 | 92.7909 | 99.775 | 13.1 |
| **21-Jul-15** | NaN | NaN | NaN | NaN | 0.808520 | 4.9 | 308.893 | 12.74146 | 87.8904 | 99.63819 | 8.6 |
| **22-Jul-15** | NaN | NaN | NaN | NaN | 0.547784 | 4.214 | 171.206 | 12.22382 | 84.4818 | 99.80347 | 1.8 |
| **23-Jul-15** | NaN | NaN | NaN | NaN | 0.535097 | 5.292 | 150.735 | 13.06222 | 77.0121 | 99.68125 | 9.1 |
| **24-Jul-15** | NaN | NaN | NaN | NaN | 0.867131 | 8.72 | 188.808 | 10.67465 | 81.5360 | 99.85208 | 1.4 |
| **25-Jul-15** | NaN | NaN | NaN | NaN | 0.666916 | 4.704 | 179.576 | 12.05154 | 72.4041 | 100.0424 | 0 |
| **26-Jul-15** | NaN | NaN | NaN | NaN | 1.068361 | 5.39 | 146.830 | 14.29042 | 69.8451 | 100.2354 | 0 |
| **27-Jul-15** | NaN | NaN | NaN | NaN | 0.635152 | 4.41 | 132.417 | 14.9584 | 68.0949 | 100.3785 | 0.1 |
| **28-Jul-15** | NaN | NaN | NaN | NaN | 0.581277 | 7.644 | 185.623 | 14.06083 | 64.2234 | 100.5472 | 0.7 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
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| **29-Jul-15** | NaN | NaN | NaN | NaN | 0.996312 | 9.51 | 190.774 | 13.2739 | 59.0803 | 100.959 | 0.2 |
| **30-Jul-15** | NaN | NaN | NaN | NaN | 0.749145 8 | 5.194 | 128.230 | 15.24597 | 66.0565 | 100.8181 | 0.3 |
| **31-Jul-15** | NaN | NaN | NaN | NaN | 0.637506 | 6.076 | 187.634 | 13.5034 | 81.6317 | 100.7139 | 5.5 |
| **01-Aug-15** | NaN | NaN | NaN | NaN | 0.699486 1 | 6.272 | 189.514 | 12.56906 | 76.6845 | 100.6632 | 0.1 |
| **02-Aug-15** | NaN | NaN | NaN | NaN | 0.771493 | 5.782 | 264.216 | 11.07169 | 84.8192 | 100.4104 | 2.5 |
| **03-Aug-15** | NaN | NaN | NaN | NaN | 0.436875 | 5.096 | 235.247 | 11.74757 | 93.0833 | 100.2111 | 44.5 |
| **04-Aug-15** | NaN | NaN | NaN | NaN | 1.016118 | 6.272 | 301.390 | 14.02924 | 73.3666 | 100.6174 | 0.4 |
| **05-Aug-15** | NaN | NaN | NaN | NaN | 0.992638 9 | 6.468 | 290.424 | 15.87167 | 69.0966 | 100.3569 | 0 |
| **06-Aug-15** | NaN | NaN | NaN | NaN | 0.819513 | 4.606 | 184.701 | 17.96799 | 63.3686 | 99.96528 | 0 |
| **07-Aug-15** | NaN | NaN | NaN | NaN | 0.641375 | 3.822 | 176.900 | 16.32597 | 72.1558 | 99.99236 | 0 |
| **08-Aug-15** | NaN | NaN | NaN | NaN | 0.765972 | 5.684 | 168.872 | 17.09715 | 66.6903 | 100.1042 | 5.1 |
| **09-Aug-15** | NaN | NaN | NaN | NaN | 0.968243 1 | 6.272 | 136.921 | 15.66194 | 81.5356 | 100.2139 | 0.1 |
| **10-Aug-15** | NaN | NaN | NaN | NaN | 0.624486 | 7.056 | 173.425 | 14.01785 | 79.0872 | 100.1965 | 7.1 |
| **11-Aug-15** | NaN | NaN | NaN | NaN | 0.660423 6 | 4.606 | 147.343 | 14.29917 | 71.2900 | 100.2562 | 0 |
| **12-Aug-15** | NaN | NaN | NaN | NaN | 1.196958 | 8.23 | 164.944 | 13.79799 | 80.7372 | 100.216 | 0.1 |
| **13-Aug-15** | NaN | NaN | NaN | NaN | 1.173861 | 7.742 | 299.533 | 11.37526 | 66.0791 | 100.766 | 0.5 |
| **14-Aug-15** | NaN | NaN | NaN | NaN | 0.810395 | 6.174 | 274.933 | 12.14994 | 62.4875 | 101 | 0 |
| **15-Aug-15** | NaN | NaN | NaN | NaN | 0.700986 1 | 4.41 | 203.637 | 11.78328 | 68.5641 | 101.0792 | 0 |
| **16-Aug-15** | NaN | NaN | NaN | NaN | 0.620243 | 4.704 | 139.766 | 15.29486 | 64.6663 | 100.7903 | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **17-Aug-15** | NaN | NaN | NaN | NaN | 0.6772986 | 5.978 | 183.839 | 14.97181 | 65.8948 | 100.8292 | 0 |
| **18-Aug-15** | NaN | NaN | NaN | NaN | 1.136306 | 9.6 | 220.146 | 16.92819 | 49.9548 | 100.0076 | 0 |
| **19-Aug-15** | NaN | NaN | NaN | NaN | 0.9438194 | 9.31 | 300.975 | 12.1113 | 62.4436 | 100.0861 | 0.1 |
| **20-Aug-15** | NaN | NaN | NaN | NaN | 0.845736 | 6.272 | 317.748 | 9.74391 | 87.4731 | 100.3507 | 6.9 |
| **21-Aug-15** | NaN | NaN | NaN | NaN | 0.6785694 | 5.39 | 145.229 | 11.37249 | 75.4347 | 100.6743 | 0.3 |
| **22-Aug-15** | NaN | NaN | NaN | NaN | 1.234965 | 7.35 | 137.160 | 10.42086 | 81.8588 | 100.2729 | 1 |
| **23-Aug-15** | NaN | NaN | NaN | NaN | 0.6013194 | 5.488 | 177.012 | 9.520021 | 73.2860 | 100.3854 | 0.1 |
| **24-Aug-15** | NaN | NaN | NaN | NaN | 0.587847 | 4.018 | 212.919 | 11.18244 | 72.2254 | 100.6715 | 5.9 |
| **25-Aug-15** | NaN | NaN | NaN | NaN | 1.018278 | 5.782 | 284.288 | 9.307951 | 74.3269 | 101.0986 | 0 |
| **26-Aug-15** | NaN | NaN | NaN | NaN | 0.610479 | 4.802 | 156.126 | 10.63296 | 73.2025 | 100.4854 | 0 |
| **27-Aug-15** | NaN | NaN | NaN | NaN | 0.5854097 | 3.626 | 209.957 | 10.89115 | 79.5047 | 99.61597 | 0.7 |
| **28-Aug-15** | NaN | NaN | NaN | NaN | 0.920493 | 6.076 | 147.714 | 11.81792 | 84.4763 | 99.33056 | 2.1 |
| **29-Aug-15** | NaN | NaN | NaN | NaN | 1.648021 | 6.958 | 132.211 | 12.45451 | 81.4568 | 98.30139 | 5.3 |
| **30-Aug-15** | NaN | NaN | NaN | NaN | 1.602882 | 9.6 | 136.019 | 8.724208 | 78.8782 | 98.25694 | 1.6 |
| **31-Aug-15** | NaN | NaN | NaN | NaN | 0.6088819 | 6.566 | 212.579 | 4.94334 | 72.5112 | 99.04236 | 0.1 |
| **01-Sep-15** | NaN | NaN | NaN | NaN | 1.032194 | 9.21 | 247.155 | 7.644757 | 65.7921 | 99.46389 | 0 |
| **02-Sep-15** | NaN | NaN | NaN | NaN | 0.7103611 | 6.37 | 266.290 | 7.365028 | 71.6802 | 100.4792 | 0 |
| **03-Sep-15** | NaN | NaN | NaN | NaN | 0.586756 | 6.566 | 214.918 | 5.205625 | 73.5982 | 101.059 | 0 |
| **04-Sep-15** | NaN | NaN | NaN | NaN | 0.7907917 | 5.096 | 167.368 | 7.329097 | 68.4067 | 100.6694 | 0 |
| **05-Sep-15** | NaN | NaN | NaN | NaN | 0.412111 | 4.41 | 156.398 | 6.567306 | 72.9421 | 100.5063 | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| **06-Sep-15** | NaN | NaN | NaN | NaN | 0.5357292 | 5.292 | 121.386 | 8.028292 | 76.6949 | 100.4632 | 0 |
| **07-Sep-15** | NaN | NaN | NaN | NaN | 0.872180 | 7.35 | 210.627 | 10.28079 | 72.5729 | 100.2521 | 0.8 |
| **08-Sep-15** | NaN | NaN | NaN | NaN | 0.5803958 | 3.528 | 212.153 | 9.62725 | 70.7096 | 100.2069 | 0 |
| **09-Sep-15** | NaN | NaN | NaN | NaN | 0.811659 | 5.782 | 141.615 | 9.660278 | 76.2198 | 100.5597 | 0 |
| **10-Sep-15** | NaN | NaN | NaN | NaN | 0.97325 | 6.762 | 161.945 | 14.93167 | 68.7059 | 100.5306 | 0 |
| **11-Sep-15** | NaN | NaN | NaN | NaN | 0.863972 | 6.664 | 199.335 | 12.88599 | 75.4153 | 100.2847 | 3.2 |
| **12-Sep-15** | NaN | NaN | NaN | NaN | 0.8560347 | 8.33 | 255.297 | 9.407056 | 64.6444 | 100.2451 | 0 |
| **13-Sep-15** | NaN | NaN | NaN | NaN | 0.694069 | 9.02 | 212.161 | 6.593132 | 72.5805 | 100.1438 | 0 |
| **14-Sep-15** | NaN | NaN | NaN | NaN | 0.5903333 | 3.92 | 219.027 | 4.559993 | 79.3133 | 99.71597 | 0 |
| **15-Sep-15** | NaN | NaN | NaN | NaN | 0.388034 | 5.782 | 165.241 | 4.215924 | 77.2953 | 99.67778 | 0 |
| **16-Sep-15** | NaN | NaN | NaN | NaN | 0.5277847 | 5.39 | 153.843 | 5.872069 | 81.2814 | 99.74722 | 0 |
| **17-Sep-15** | NaN | NaN | NaN | NaN | 1.205264 | 9.21 | 148.491 | 7.181035 | 76.3104 | 99.51181 | 0 |
| **18-Sep-15** | NaN | NaN | NaN | NaN | 1.867917 | 12.54 | 140.067 | 7.804285 | 82.6492 | 98.80833 | 5.5 |
| **19-Sep-15** | NaN | NaN | NaN | NaN | 0.650784 | 8.04 | 202.261 | 3.249583 | 70.8284 | 99.40972 | 0 |
| **20-Sep-15** | NaN | NaN | NaN | NaN | 0.5421806 | 5.096 | 222.157 | 1.684799 | 67.2787 | 100.0493 | 0 |
| **21-Sep-15** | NaN | NaN | NaN | NaN | 0.705638 | 6.566 | 177.002 | 5.040285 | 73.6652 | 100.1826 | 1.8 |
| **22-Sep-15** | NaN | NaN | NaN | NaN | 0.668625 | 4.018 | 147.743 | 4.916167 | 88.5708 | 100.0667 | 3.4 |
| **23-Sep-15** | NaN | NaN | NaN | NaN | 0.620222 | 5.39 | 150.887 | 5.044729 | 89.3654 | 99.98819 | 5.3 |
| **24-Sep-15** | NaN | NaN | NaN | NaN | 0.9158472 | 6.076 | 156.112 | 3.655729 | 92.1732 | 99.77986 | 3.9 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **25-Sep-15** | NaN | NaN | NaN | NaN | 0.967784 | 4.704 | 137.981 | 4.221313 | 69.2267 | 100.041 | 0 |
| **26-Sep-15** | NaN | NaN | NaN | NaN | 0.7660347 | 5.194 | 213.965 | 4.887521 | 71.7959 | 100.0924 | 1.1 |
| **27-Sep-15** | NaN | NaN | NaN | NaN | 0.488076 | 6.762 | 154.226 | 6.989306 | 75.6504 | 100.6028 | 0 |
| **28-Sep-15** | NaN | NaN | NaN | NaN | 0.6099722 | 4.508 | 163.998 | 7.865528 | 88.7485 | 100.2472 | 1 |
| **29-Sep-15** | NaN | NaN | NaN | NaN | 1.260028 | 7.938 | 142.380 | 11.85229 | 74.3331 | 99.97222 | 0 |
| **30-Sep-15** | NaN | NaN | NaN | NaN | 1.488785 | 7.742 | 215.706 | 12.31232 | 63.5348 | 100.3118 | 2.5 |
| **01-Oct-15** | NaN | NaN | NaN | NaN | 1.919722 | 11.66 | 295.542 | 5.028007 | 75.8631 | 101.2264 | 0.7 |
| **02-Oct-15** | NaN | NaN | NaN | NaN | 0.8428194 | 10.19 | 256.084 | 0.9520347 | 71.3685 | 102.0014 | 0 |
| **03-Oct-15** | NaN | NaN | NaN | NaN | 0.386409 | 3.234 | 188.543 | 1.467778 | 71.9401 | 101.3153 | 0.1 |
| **04-Oct-15** | NaN | NaN | NaN | NaN | 0.8849861 | 3.822 | 240.469 | 3.990701 | 64.2011 | 100.7431 | 0 |
| **05-Oct-15** | NaN | NaN | NaN | NaN | 0.531625 | 4.116 | 202.174 | 2.359875 | 68.1434 | 100.5958 | 0 |
| **06-Oct-15** | NaN | NaN | NaN | NaN | 0.558520 | 4.704 | 178.028 | 3.676153 | 71.5482 | 100.3687 | 0 |
| **07-Oct-15** | NaN | NaN | NaN | NaN | 0.737034 | 5.488 | 143.826 | 7.523076 | 71.97208 | 100.4854 | 0 |
| **08-Oct-15** | NaN | NaN | NaN | NaN | 2.314111 | 8.62 | 124.687 | 10.32056 | 91.0022 | 99.61319 | 10.4 |
| **09-Oct-15** | NaN | NaN | NaN | NaN | 3.131386 | 12.05 | 132.740 | 10.73489 | 88.41477 | 98.09318 | 8.4 |
| **10-Oct-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **11-Oct-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **12-Oct-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **13-Oct-15** | NaN | NaN | NaN | NaN | 1.7722 | 8.62 | 174.35 | 8.0686 | 54.18 | 100.5 | 0 |
| **14-Oct-15** | NaN | NaN | NaN | NaN | 0.96175 | 2.254 | 146.733 | 8.60525 | 45.1 | 101.4 | 0 |
| **15-Oct-15** | NaN | NaN | NaN | NaN | 0.595666 | 1.274 | 157.85 | -39.93 | 0.068 | 100.9 | 0.4 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| **16-Oct-15** | NaN | NaN | NaN | NaN | 0.47725 | 1.96 | 140.428 | -5.12575 | 55.282 | 100.6625 | 0.2 |
| **17-Oct-15** | NaN | NaN | NaN | NaN | 0.679 | 2.94 | NaN | 6.009 | 87.6 | 99.7 | 0 |
| **18-Oct-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **19-Oct-15** | NaN | NaN | NaN | NaN | 1.001125 | 4.312 | 252.895 | 9.830708 | 61.5895 | 100.1 | 0 |
| **20-Oct-15** | NaN | NaN | NaN | NaN | 3.414333 | 8.72 | 132.4 | 7.782667 | 82.7 | 99.4 | 0 |
| **21-Oct-15** | NaN | NaN | NaN | NaN | 1.771143 | 6.076 | 194.338 | - | 59.291 | 99.72143 | 0 |
| **22-Oct-15** | NaN | NaN | NaN | NaN | 1.1255 | 3.822 | 136.070 | -8.5125 | 54.2165 | 100.5357 | 0 |
| **23-Oct-15** | NaN | NaN | NaN | NaN | 0.732 | 3.43 | 194.316 | 2.074333 | 76.5044 | 100.9444 | 0.1 |
| **24-Oct-15** | NaN | NaN | NaN | NaN | 0.766823 | 4.802 | 199.625 | 0.9378471 | 74.4925 | 100.9518 | 0 |
| **25-Oct-15** | NaN | NaN | NaN | NaN | 0.793365 | 10.19 | 215.789 | 1.855846 | 68.5044 | 100.4962 | 1.4 |
| **26-Oct-15** | NaN | NaN | NaN | NaN | 1.057118 | 10.09 | 264.771 | -2.918562 | 74.3367 | 101.1257 | 0.2 |
| **27-Oct-15** | NaN | NaN | NaN | NaN | 0.646986 | 4.214 | 241.758 | -1.029021 | 75.4227 | 100.4833 | 0 |
| **28-Oct-15** | NaN | NaN | NaN | NaN | 0.344148 | 2.352 | 252.666 | - 0.5915313 | 88.8561 | 99.59219 | 0.5 |
| **29-Oct-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **30-Oct-15** | NaN | NaN | NaN | NaN | 1.371 | 2.744 | NaN | 5.438 | 74.94 | 98.3 | 0 |
| **31-Oct-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **01-Nov-15** | NaN | NaN | NaN | NaN | 1.981 | 4.41 | 327.4 | -5.007 | 64.9266 7 | 100.9 | 0.1 |
| **02-Nov-15** | NaN | NaN | NaN | NaN | 0.606 | 4.704 | 271.121 | -4.840556 | 80.1237 | NaN | 2 |
| **03-Nov-15** | NaN | NaN | NaN | NaN | 0.709083 | 3.528 | 197.682 | - | 81.2077 8 | NaN | 0.2 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| **04-Nov-15** | NaN | NaN | NaN | NaN | 1.093514 | 6.762 | 231.142 | - | 80.8594 | NaN | 0.9 |
| **05-Nov-15** | NaN | NaN | NaN | NaN | 0.335673 | 4.312 | 182.248 | -6.036042 | 79.4373 | NaN | 0 |
| **06-Nov-15** | NaN | NaN | NaN | NaN | 0.821444 | 7.84 | 209.199 | -1.832896 | 90.7256 | NaN | 1.6 |
| **07-Nov-15** | NaN | NaN | NaN | NaN | 0.690423 | 3.234 | 273.082 | -1.07034 | 86.0481 | NaN | 2 |
| **08-Nov-15** | NaN | NaN | NaN | NaN | 0.561014 | 2.646 | 288.6515 | -3.605647 | 86.3964 | NaN | 0 |
| **09-Nov-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **10-Nov-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **11-Nov-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **12-Nov-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **13-Nov-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **14-Nov-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **15-Nov-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **16-Nov-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **17-Nov-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **18-Nov-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **19-Nov-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **20-Nov-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **21-Nov-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **22-Nov-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| **23-Nov-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **24-Nov-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **25-Nov-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **26-Nov-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **27-Nov-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **28-Nov-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **29-Nov-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **30-Nov-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **01-Dec-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **02-Dec-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **03-Dec-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **04-Dec-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **05-Dec-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **06-Dec-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **07-Dec-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **08-Dec-15** | NaN | NaN | NaN | NaN | 1.159556 | 3.038 | 110.925 | -1.354667 | 89.9888 | NaN | 0 |
| **09-Dec-15** | NaN | NaN | NaN | NaN | 0.499284 | 3.234 | 213.758 | -2.87691 | 89.87014 | NaN | 0 |
| **10-Dec-15** | NaN | NaN | NaN | NaN | 0.691227 | 3.234 | 309.025 | -5.865633 | 87.2455 | NaN | 0 |
| **11-Dec-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **12-Dec-15** | NaN | NaN | NaN | NaN | 2.271667 | 5.586 | 320.18 | -13.04 | 69.6616 | NaN | 0 |
| **13-Dec-15** | NaN | NaN | NaN | NaN | 1.336222 | 4.41 | 290.162 | -16.31556 | 67.3888 | NaN | 0 |
| **14-Dec-15** | NaN | NaN | NaN | NaN | 0.4822 | 1.568 | 206.865 | -17.862 | 65.84 | NaN | 0 |
| **15-Dec-15** | NaN | NaN | NaN | NaN | 0.459285 | 1.397 | 119.15 | -15.17714 | 72.38 | NaN | 0 |
| **16-Dec-15** | NaN | NaN | NaN | NaN | 0.218769 | 1.078 | 173.9675 | -10.78462 | 62.3738 | NaN | 0 |
| **17-Dec-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| **18-Dec-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **19-Dec-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **20-Dec-15** | NaN | NaN | NaN | NaN | 0.2716 | 0.98 | 170.456 | -8.666 | 76.822 | NaN | 0 |
| **21-Dec-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **22-Dec-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **23-Dec-15** | NaN | NaN | NaN | NaN | 2.137111 | 4.704 | 325.387 | -23.23778 | 62.7988 | NaN | 0 |
| **24-Dec-15** | NaN | NaN | NaN | NaN | 1.4992 | 4.018 | 308.912 | -21.4496 | 61.1944 | NaN | 0 |
| **25-Dec-15** | NaN | NaN | NaN | NaN | 1.191909 | 3.038 | 331.39 | -19.30182 | 59.27 | NaN | 0 |
| **26-Dec-15** | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | NaN | 0 |
| **27-Dec-15** | NaN | NaN | NaN | NaN | 1.320125 | 2.842 | 325.328 | -25.35125 | 58.865 | NaN | 0 |
| **28-Dec-15** | NaN | NaN | NaN | NaN | 1.044 | 3.528 | 321.4 | -22.20455 | 55.8754 | NaN | 0 |
| **29-Dec-15** | NaN | NaN | NaN | NaN | 0.359181 | 1.47 | 249.099 | -24.67 | 59.1027 | NaN | 0 |
| **30-Dec-15** | NaN | NaN | NaN | NaN | 0.209181 | 0.98 | 255.87 | -20.55909 | 54.2209 1 | NaN | 0 |